DEPARTMENT OF THE INTERIOR—CANADA

Hon. CHARLES STEWART, Minister - W. W. CORY, C.M.G., Deputy Minister

DOMINION WATER POWER BRANCH

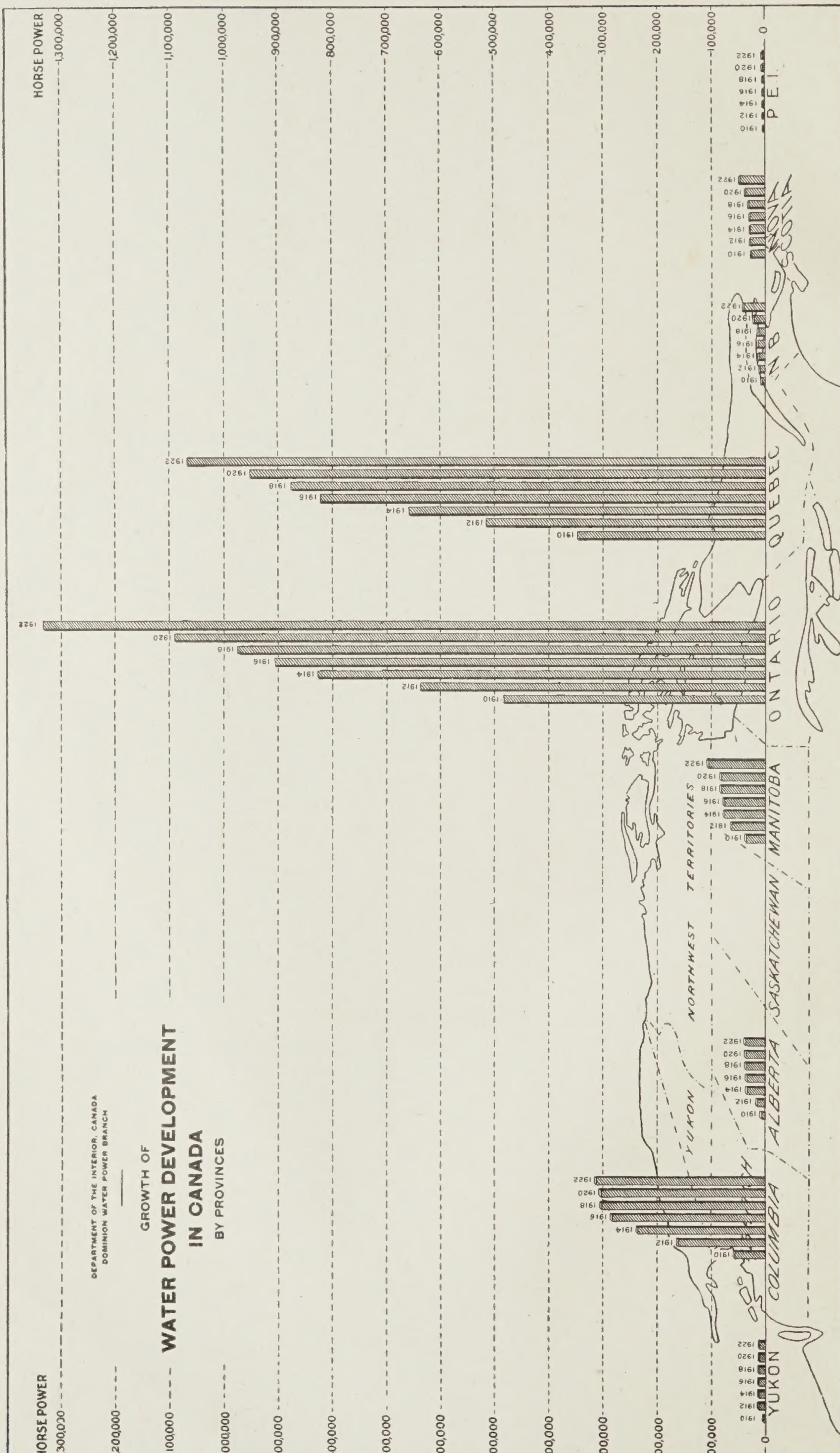
J. B. CHALLIES, C.E., Director

ANNUAL REPORT

1921-22

OTTAWA
F. A. ACLAND
PRINTER TO THE KING'S MOST EXCELLENT MAJESTY
1923

PLATE I



DEPARTMENT OF THE INTERIOR, CANADA
DOMINION WATER POWER BRANCH
GROWTH OF
WATER POWER DEVELOPMENT
IN CANADA
BY PROVINCES
HORSE POWER
1,300,000
1,200,000
1,100,000
1,000,000
900,000
800,000
700,000
600,000
500,000
400,000
300,000
200,000
100,000
0
1910
1912
1914
1916
1918
1920
1922
YUKON
COLUMBIA
ALBERTA
SASKATCHEWAN
MANITOBA
NORTHWEST TERRITORIES
ONTARIO
QUEBEC
N.B.
NOVA SCOTIA
P.E.I.

DEPARTMENT OF THE INTERIOR, CANADA
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DOMINION WATER POWER BRANCH
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ANNUAL REPORT

OF THE

DOMINION WATER POWER BRANCH

FOR THE

Fiscal Year Ending March 31, 1922

OTTAWA
F. A. ACLAND
PRINTER TO THE KING'S MOST EXCELLENT MAJESTY
1923

54389—1½

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ANNUAL REPORT

OF THE

DOMINION WATER POWER BRANCH

PART 1

SCOPE OF ACTIVITIES

PART I

SCOPE OF ACTIVITIES

During the past fiscal year the Dominion Water Power Branch completed its tenth year as a distinct branch of the department and the year that has just closed marks the fifteenth since the administration of water-powers as a distinct resource was first undertaken by the Dominion.

The past year was also the first complete year since all the hydrometric survey work of the department was made a responsibility of this branch. A Dominion Hydrometric Survey organization extending from coast to coast is now firmly established.

Organization and Scope

The activities of the Dominion Water Power Branch are both administrative and investigatory. The administrative phase of the work arises from the proprietary interest of the Dominion in the water-power resources in the provinces of Alberta, Saskatchewan and Manitoba, the Northwest and Yukon Territories, and in the Railway Belt of British Columbia. In this connection the department must of necessity secure such fundamental engineering and economic data as will enable it to consider applications for power privileges, and to control the development, the distribution and the sale of hydro-electric energy. This is the prime responsibility of the branch.

Throughout the balance of the Dominion the water-powers are vested in the provinces and investigatory work is carried on in co-operation with the respective provincial authorities charged with their administration. The branch also co-operates extensively with federal departments and commissions other than the Department of the Interior, the services of its engineering field staff, in the interests of general economy and efficiency, being made available to such other departments and commissions.

In respect to its administrative responsibilities, the policy of the Department of the Interior, through its Dominion Water Power Branch, is in brief,—

> To encourage the development of our water-powers; to secure well in advance of prospective development, full and reliable information respecting the water supply for, the physical characteristics of, and the general conditions affecting the development of all economic power sites; to place all such information secured at the disposal of the applicant and of the general public, to discourage and prevent the initiation and development of uneconomic and wasteful projects; to ensure that each site developed shall utilize or provide for the future utilization of the maximum available power; to ensure that river systems are developed along comprehensive lines wherein each unit is a component link in a system; to ensure the development of existing plants to their limit when the market demands; to ensure adequate storage measures in the interests of all powers affected; to prevent unnecessary and costly duplication of expenditures on the part of competing plants; to protect the public from inadvisable power schemes and ill-designed plants and dams; to safeguard the public from monopolistic control by regulation and periodical revision of rates; to see to the early carrying into effect of agreements issued by the department for the development of power; and to promote in every way the fullest conservation of the Dominion power resources.

In respect to the direct and co-operative *investigatory work* the objective of the department is two-fold:—

1. To co-ordinate and systematize the gathering of power and general water-resources information from coast to coast.

2. To create a centralizing agency for the efficient analysis of the power and general water resources of the Dominion in relation to location and use of power—to industry; to industrial centres; industrial opportunities, transportation systems—rail and navigation; mineral resources; timber resources; coal and fuel supplies; electro-chemical and electro-metallurgical opportunities; irrigation, drainage and reclamation projects; alternative sources of power; and to the use of and market for power in general and to compile the material into immediately available and usable form and for whatever purpose required.

For the proper and efficient carrying out of its administrative and investigatory work, the department has a trained staff of officers, the greater number of whom are engineers who have been specially trained in the various phases of power investigation and analysis. In addition to this organization, the department, through co-operative agreements, works in intimate and direct co-operation with provincial power authorities. The department has in this manner practically effected a consolidation of federal and provincial investigatory effort in respect to the determination and analysis of water resources data.

The co-operative facilities for water resources investigation work throughout the Dominion are as follows:—

British Columbia.—The local organization of the Dominion Water Power Branch, with headquarters at 119 Pender Street West, Vancouver, carries on a broadly planned hydrometric survey and systematically secures fundamental data necessary to a complete analysis of the water-power resources, in accordance with the terms of a co-operative agreement with the Provincial Water Rights Branch of British Columbia.

Alberta and Saskatchewan.—The local organization of the Dominion Water Power Branch, with headquarters at 513 Eighth Avenue West, Calgary, carries on direct administrative work throughout all parts of the two provinces, in virtue of the proprietary interest of the department in their water-power resources. The investigatory work comprises a comprehensive hydrometric survey and a systematic and exhaustive field and office analysis of the water-power resources of the two provinces.

Manitoba.—The local organization of the branch with headquarters at 231 Chambers of Commerce Block, Winnipeg, carries on direct admiistrative work throughout the province, in virtue of the proprietary interest of the department in the provincial water-power resources. A comprehensive hydrometric survey is maintained, as well as a systematic and exhaustive field and office analysis of the provincial water-power resources. In the interests of administrative economy the investigatory work carried on through the Manitoba office has been extended to cover that portion of Ontario lying west of and including lake Nipigon.

Ontario.—The local organization of the branch, with headquarters at Ottawa, carries on a comprehensive hydrometric survey and systematically secures fundamental water resources data in accordance with the terms of a co-operative agreement with the Ontario authorities. The closest possible co-operation is maintained with the staff of the Ontario Hydro-Electric Power Commission.

Quebec.—While no formal agreement has as yet been entered into with the province of Quebec, relationships have been established between the branch and the Quebec Streams Commission, under which there is a free exchange of data and through which a co-operative analysis of the provincial water resources is proceeding. A co-operative agreement with the Quebec authorities similar to that in effect in other provinces is under consideration.

The Maritime Provinces.—The local organization of the branch, headquarters at 193 Hollis Street, Halifax, in accordance with the terms of a co-operative agreement with the three respective provincial authorities of New Brunswick, Nova Scotia and Prince Edward Island, carries on a systematic hydrometric survey and a comprehensive and continuous power and storage survey of the three provinces, with a view to securing the fundamental data necessary to a complete analysis of their water power resources. In New Brunswick, the branch collaborates with the New Brunswick Electric Power Commission; in Nova Scotia, with the Nova Scotia Power Commission; and in Prince Edward Island with the provincial authorities.

Yukon and Northwest Territories.—Administrative and investigatory work in the Territories form a direct responsibility of the Dominion Water Power Branch in virtue of the proprietary interest of the department in their water-power resources. Investigatory work in the Yukon is handled through the British Columbia organization. In the balance of the Territories such work is directed from head office, as exigencies demand.

The field organization of the department is based upon and built up around the Dominion Hydrometric Survey through which systematic and continuous stream measurement studies are carried on throughout the Dominion, with the exception of the province of Quebec, where similar work is undertaken by the Quebec Streams Commission. The hydrometric survey field staff are specially trained in every class of water-power investigatory work, and, in addition to their stream measurement activities, are employed in a systematic and continuous field analysis of the country's water-power resources. The data systematically accumulated through this work and through co-operative agreements and studies with other organizations is collated, analyzed and standardized in the head office of the branch at Ottawa.

As a result, there is now on file in the offices of the Dominion Water Power Branch general and detailed information in respect to runoff and power possibilities of the more important power rivers throughout the Dominion. This data is constantly being brought up to date as new or later information is received and is promptly available for reference purposes to all interested in the utilization of the water-powers of the Dominion.

Lake of the Woods Control Board

Regulation of the levels and outflow of lake of the Woods, was, as in the previous year, a responsibility of Lake of the Woods Control Board.

Under the terms of the Lake of the Woods Regulation Act, all dams, structures or other works now constructed or hereafter constructed on any outlet of lake of the Woods, the Winnipeg river at or above its junction with the English river and the English river at the outlet of and below lac Seul are declared to be for the general advantage of Canada. Furthermore, authority is given the Governor in Council to make and enforce such regulations for the operation of such works as to ensure at all times the most dependable flow of the waters of the Winnipeg and English rivers and to ensure the regulation of

the level of the lake of the Woods in conformity with the recommendations of the International Joint Commission or with any agreement with reference thereto which may be made between Canada and the United States.

REGULATIONS UNDER THE LAKE OF THE WOODS REGULATION ACT

1. All dams, structures and other works of whatsoever description which have heretofore been or may hereafter be constructed in, upon, over, about or across,—

(*a*) any outlet of the lake of the Woods;
(*b*) the Winnipeg river at or above its junction with English river,

which do or may or can in anywise control, regulate or affect the outflow of water from the lake of the Woods, or the natural levels of the water of the said lake at any time, or the natural flow of the water in the Winnipeg river at any time, shall each of them be constructed, maintained, improved, repaired and operated in such manner as,—

(*a*) to secure at all times the most dependable flow and the most advantageous and beneficial use of the waters of the Winnipeg river;
(*b*) to regulate and control the outflow of the waters of the lake of the Woods so as to maintain the level of the said lake between the elevations recommended by the report of the International Joint Commission of June 12, 1917, or between such elevations as may be agreed upon by the United States and Canada, and so that the obligations, relating to the level of the lake of the Woods, of Canada, or of any of the provinces of Canada, as part of the British Dominions beyond the seas, towards the United States, arising out of treaty made or to be made between His Majesty the King of the United Kingdom of Great Britain and Ireland and of the British Dominions beyond the seas, Emperor of India, and the United States, may be duly performed.

2. The Lake of the Woods Control Board shall, in addition to such duties as have been or may from time to time be assigned to it,—

(*a*) Obtain where possible from existing departmental agencies, and where necessary by original investigations, all meteorological, hydrological and other essential data relating to the watershed;
(*b*) Record, co-ordinate and maintain all meteorological, hydrological or other essential data in available and usuable form and have the same made available in printed form or otherwise to all interested persons, companies or municipalities;
(*c*) Determine the levels and flows necessary to be maintained from day to day or for any other period of time so as to insure the regulation of levels and flows in conformity with regulation No. (1) as set out above.
(*d*) Issue to those persons or authorities directing, controlling or maintaining any of the aforementioned dams, structures or other works, orders with respect to the levels and flows determined by the board as well as the manner or method by which they shall be maintained.

3. The board may from time to time confer with any municipalities, companies, bodies or persons affected by or interested in the regulations of water levels and discharges by the board respecting any matter arising from such regulations and shall from time to time hear, receive and investigate any complaints or representations from such municipalities, companies, bodies or persons respecting such regulations.

Operations of the board throughout the year have as heretofore involved the continuous collection and study of all hydrological records relating to the watershed.

During spring break-up, no extreme conditions were encountered though it was necessary in the month of April to provide maximum outflow capacity at the Norman dam. Subsequently there was a period of deficient precipitation, and outflow from the lake was reduced in the last week of May from 23,000 second-feet to 15,000 second-feet. A further reduction of 5,000 second-feet was made on June 22, and again on August 8 the total outflow was reduced to 8,000 second-feet. Notwithstanding this low rate of outflow, the supply was so deficient that lake level dropped from elevation 1059·5 on August 1 to elevation 1058·95 by November 21. With freeze-up the inflow was augmented and lake stage throughout the past winter has increased slightly.

On the whole, excellent results were secured in the past year's regulation; the fluctuation in lake level was maintained within a one-foot range, while at the same time all water requirements of power users were fulfilled.

Water Power Regulations and Legal Research

The translation of foreign acts and regulations has been continued during the year and a reasonably complete set of the water-power laws now in force in Norway, Sweden, Germany, Austria, Switzerland, France, Italy, Spain and Portugal, together with the more important regulations, instructions and forms of concession thereunder has now been secured in English and indexed for comparative study.

The importance of this study lies in the fact that the use of water in most countries has hitherto been governed by the common law of that country based in almost every case upon riparian ownership. As the uses of water for irrigation and domestic supply developed the common law was amended in certain particulars, but the use of water on a large scale for power purposes which has grown up since the comparatively recent solution of the problem of long-distance transmission of electricity has brought about conditions which mere amendments to existing laws is quite inadequate to govern; consequently each of these countries, realizing that its former law was entirely inadequate to encourage and control the modern water-power industry, has passed new laws within a very recent date, most of them in fact since the close of the Great War. Beginning with the Swiss Water Act of 1916, each country in turn has produced new enactments in close succession, the most recent being the French and Italian Regulations of 1920. These latter with their supplementary decrees were translated during the past year; they contain many original and interesting features and are of particular interest to water-power administrators.

The revised Dominion Water Power Regulations, pursuant to Section 12 of the Dominion Water Power Act, 1919, which have been in course of preparation for some years, were completed during the year and were approved by the Governor in Council on October 31, 1921 (P.C. 4034). The translations referred to above were found of great value in drafting the new regulations which it is believed will be found just in their essential features and adequate in scope for many years to come.

The new regulations have been prepared with two main principles in view, namely, that the water-powers and the lands essential to their development now vested in the Crown should remain vested in the Crown for ever, and that these same lands and water-powers should be made available for development under lease on terms sufficiently generous to ensure their development and beneficial use as soon as economically desirable while at the same time adequately protecting the interests of the public by providing for the control of rates and rentals. These objects are to be attained by issuing licenses for

the development of the power and leases for the lands occupied for a fixed number of years subject to renewal under the laws and regulations then in force or to the payment of just predetermined compensation if the license terminates without being renewed at the option of the Government.

No license will be granted until sufficient information has been supplied to show exactly what it is proposed to do, and not until the engineering and economic aspects of the project are fully understood and approved.

It has frequently been objected by those interested in water-power development that capital for that purpose cannot be obtained on reasonable terms unless the licensee has received a definite and binding grant from the Crown and until he received such a grant the money required for construction purposes will not be forthcoming; on the other hand the Minister as representing the Crown would naturally be unwilling to give the licensee any exclusive rights for a number of years until he was absolutely assured of the licensee's ability and intention to perform in good faith the terms agreed upon, and this can as a rule only be proved by the construction of the development works or at least by a substantial investment on the part of the licensee in the proposed undertaking. This difficulty has been provided for in the Dominion Regulations by the issue of two forms of license, the interim and the final license, the former being intended to cover the survey-construction period and the latter the whole period of operation.

The interim license may be granted at a comparatively early stage of the undertaking; in fact, as soon as the director is satisfied that the proposed development is desirable from an engineering and economic standpoint and will accord with the most beneficial utilization of the resources of the stream, and that the applicant's financial standing is satisfactory, he may recommend the issue of the interim license, after the requirements in regard to publication and hearings have been complied with. The applicant may thus receive his interim license before he is required to expend any money on the undertaking beyond what is necessary for the preliminary surveys and plans. Moreover, the interim license contains a definite statement that upon the completion of the development ready to deliver power and due compliance with the conditions laid down, a final license will be issued to replace the former one, and it also embodies the principal conditions of the final license such as the term, the rental during the first twenty years, and the quantity of water which may be stored or used. The licensee is thus placed in a favourable position to secure the capital required for the construction of the works, as by the time the money is needed the conditions under which the site is to be leased during the whole period of the concession are determined and fixed, and no uncertainties are left which might prejudice the investment.

There is one important difference between the licensee's position as the holder of an interim or a final license; in the latter case the license cannot be cancelled for default or even seriously questioned without an order of the Exchequer Court, on the other hand an interim license may be cancelled by the minister for default without appeal, but only provided that the licensee has expended on construction less than one-quarter of the total amount specified in the license to be so expended; after he has invested one-quarter of the total in actual construction, the licensee may appeal from the minister's decision to the Exchequer Court. This provision for summary cancellation before construction has been actively begun is necessary to prevent the tying up of valuable power sites in private hands without any development being carried out. The intention of the regulations is that the water-powers should be beneficially used and not that they should lie idle under private control.

The rental to be charged for the rights granted is assessed on an output basis, according to a sliding scale by which the rate per horse-power-year decreases as the load factor increases, thus providing a direct incentive to

improve the load factor with a consequent more economical use of the water leased. The rental may be revised after twenty years and every ten years thereafter. Any changes in the rental are to be made by mutual agreement between the minister and the licensee, or if this cannot be done the matter is to be decided by an impartial board or commission.

The first cost of developing a water-power plant is usually high as compared with that of a steam plant generating an equal amount of power, it is therefore essential that the capital required for development purposes should receive reasonable protection from loss or confiscation. This is provided for in the regulations by allowing compensation to be paid for any property taken over by the Crown either at the end of the term of concession or if the license is terminated prior to that time. The basis on which compensation is allowed is the actual investment in the property necessarily used and useful in the undertaking; and this is applied in such a way that in every case after the development is completed and in operation (except in cases of serious default) the licensee is entitled to have refunded to him the actual cost of the original development and all additions which may have been made to it, less obsolescence and depreciation, when the license is terminated or if the Crown exercises its right of recapture. In addition, substantial bonuses may be allowed to meet varying conditions of termination and to cover severance losses and other intangible items. The basis of actual cost is used wherever applicable throughout the regulations, but it is applied in such a way that the result represents the present cost of the property at the time the valuation is made. This is done by a consideration of any variation in the purchasing power of a dollar which may have occurred between the date of the original expenditure and the date of the valuation, with a corresponding adjustment of the unit costs.

The licensee is required to file an annual statement showing renewals, extensions, and depreciation and giving details as to the financial position of the undertaking, thus showing clearly the progressive actual cost and providing information which may be used when the licensee is engaged in the sale of power in connection with inquiries in regard to the regulation of rates, service, the issue of securities, or the revision of rentals. The principle of a fair rate of return on the invested capital is provided for, and no revision of rental or of the rates charged by a public utility company operating under these regulations may be made which would render it impossible for the licensee to earn a fair rate of return as defined. This rate is made cumulative so that it may be applied to the early years of operation and to periods of severe depression when earnings are necessarily low. It is believed that this cumulative principle as applied to public utilities is just both to the licensee and to the public; under controlled rates the licensee is prevented from sharing in the fruits of prosperous times and should in consequence receive a measure of protection during times of stress when service has to be rendered regardless of earnings.

The regulations deal with a number of other subjects such as inspection during construction, control of maintenance and operation, steps which may be taken to secure enlarged development, contracts for the sale of power, stream regulation and control, and special provisions intended to facilitate the development of small water-powers. As the regulations are of considerable length they cannot be given here in full, but copies may be obtained from the Director of Water Power.

British Columbia Administration

In the Railway Belt of British Columbia the waters and water-powers, though belonging to the Dominion, are administered by the provincial authorities (except within the Dominion parks) under provincial Water Acts, and as the Dominion lands in the belt are administered by this department it is neces-

sary that the two administrations be harmonized. This involves close co-operation between the Dominion and provincial officials.

A considerable amount of engineering assistance is rendered the Department of Indian Affairs. One of the most important parts of this work is that in connection with the investigation of water rights appurtenant to the Indian Reserves of the province, each of the five agencies affected is dealt with separately; that for the Lytton agency was completed last year, those relating to the Kamloops, Okanagan and Kootenay agencies were completed this year and the Williams Lake agency is now under review.

The examination of water records appurtenant to lands within the Railway Belt has been continued and the work further systematized; plans are being compiled to show the lands affected in each case, and the granting of necessary rights of use or occupation of Dominion lands under the Water Lands Regulations is proceeding satisfactorily in co-operation with the British Columbia Lands Branch and the Forestry Branch.

Water Resources Index Inventory

A comprehensive description of the Index Inventory system for recording and collating the water resources data of the Dominion has been published as Water Resources Paper No. 32 and as the fundamental principles have also been described in considerable detail in previous annual reports they will not be further enumerated here.

The system has now been in actual use for the past few years both in head office and in the field offices and has proved of the greatest utility in the referencing, analysis, standardization and filing of all data relating to the subject of water resources.

Among the many phases of the work carried on by the branch to which the system has been applied there may be mentioned the complete census of developed water-power and central electric station activities, and the analysis of the undeveloped water-power resources of the stream measurement activities and of the storage studies carried on throughout the Dominion.

Much of this work has been carried on in co-operation with other organizations notably the Hydro-Electric Power Commission of Ontario and the Water Rights Branch of the British Columbia Provincial Government. As a result a very large proportion of the water resources data of the Dominion is now available in standardized and usable form for whatever purpose required. A continuous effort is being made to keep this data authentic and up to date.

Water Power Resources of Canada

Present activity in hydro-power development warrants a further statement as to the extent of Canada's water-power resources and as to the degree of their utilization. Last year has been one of substantial progress, there having been brought into operation new installation to the extent of 300,000 horse-power. The installed water wheel capacity now totals to 2,763,000 horse-power with much new construction actually under way and many further enterprises in prospect.

There is under way in the Dominion Water Power Branch a careful reanalysis and computation of the water-power resources of the Dominion. All existing stream-flow and power data, available from federal and provincial sources, have been systematically collated, analyzed and co-ordinated with a view to preparing on a uniform basis from coast to coast, revised estimates of the power available. While the analysis is not yet finally completed, sufficient progress has been made to warrant the publication of the figures given hereunder which are complete to March 1, 1922.

The total available and developed power resources are presented in a manner not heretofore adopted. A consideration of the figures will indicate that they place the water-power resources of the Dominion in a much more favourable light than have previously published compilations.

While the resources have been exhaustively analyzed in so far as the information available will permit, it should be kept in mind that only very meagre data is to hand in many districts and for many rivers.

BASIS OF COMPUTATION

The figures for undeveloped water-power listed in table 1 are based upon rapids, falls and power sites of which the actual existent drop or the head possible of concentration, is definitely known or at least well established. Many rapids and falls of greater or lesser power capacity are scattered on rivers and streams from coast to coast which are not as yet recorded, and which will only become available for tabulation as more detailed survey work is undertaken and completed. This is particularly true in the more unexplored northern districts. Nor is any consideration given to the power concentrations which are feasible on rivers and streams of gradual gradient, where economic heads may be created by the construction of power dams, excepting only at such points as definite studies have been carried out and the results made matters of record.

In brief, the figures hereunder are based on definite rapids, falls and power sites, and may be said to represent the *minimum water-power possibilities* of the Dominion.

The power estimates have been calculated on the basis of 24-hour power at 80 per cent efficiency on the basis of "Ordinary Minimum Flow" and "Estimated Flow for Maximum Development." The "Ordinary Minimum Flow" is based on the averages of the minimum flow for the lowest two consecutive seven-day periods in each year, over the period for which records are available. The "Estimated Flow for Maximum Development" is based upon the continuous power indicated by the flow of the stream for six months in the year. The actual method to determine this flow is to arrange the months of each year according to the day of the lowest flow in each. The lowest of the six high months is taken as the basic month. The average flow of the lowest seven consecutive days in this month determines the maximum for that year. The average of such maximum figures for all years in the period for which data are available is the estimated maximum used in the calculation.

This estimated maximum development is based upon the assumption that it is good commercial practice to develop wheel installation up to an amount, the continuance of which can be assured during six months of the year, on the assumption that the deficiency in power during the remainder of the year can be profitably provided from storage or by the installation of fuel-power plants as auxiliaries. The correctness or otherwise of this assumption for any particular site can only be definitely settled by the careful consideration of all circumstances and conditions pertinent to its development. The method, however, enables us to make a fairly satisfactory over-all estimate of the maximum hydraulic power vailable, as distinctive from the estimated ordinary minimum power available.

TABLE 1.—AVAILABLE AND DEVELOPED WATER-POWER IN CANADA—MARCH 1, 1922

Province	Available 24-hour power at 80 per cent efficiency		Turbine Installation h.p.
	At ordinary min. flow h.p.	At est. flow for max. dev. (Dependable for 6 months) h.p.	
1	2	3	4
British Columbia	1,931,142	5,103,460	305,315
Alberta	475,281	1,137,505	33,187
Saskatchewan	513,481	1,087,756	
Manitoba	3,270,491	5,769,444	104,147
Ontario	4,950,300	6,808,190	1,212,650
Quebec	6,915,244	11,640,052	1,015,385
New Brunswick	50,406	120,807	30,180
Nova Scotia	20,751	128,264	46,948
Prince Edward Island	3,000	5,270	1,869
Yukon and Northwest Territories	125,220	275,250	13,199
	18,255,316	32,075,998	2,762,880

The figures listed in columns 2 and 3 in the above table represent 24-hour-power and are based upon rapids, falls and power sites of which the actual existent drop or the head possible of concentration, is definitely known or at least well established. Innumerable rapids and falls of greater or lesser power capacity are scattered on rivers and streams from coast to coast which are not as yet recorded, and which will only become available for tabulation as more detailed survey work is undertaken and completed. This is particularly true in the relatively unexplored northern districts. Nor is any consideration given to the power concentrations which are feasible on rivers and streams of gradual gradient, where economic heads may be created by the construction of power dams, excepting only at such points as definite studies have been carried out and the results made matters of record.

The figures in column 4 represent the actual water-wheels installed throughout the Dominion. These figures should not be placed in direct comparison with the available power figures in columns 2 and 3 for the purpose of deducing therefrom the percentage of the available water-power resources developed to date. The actual water-wheel installation throughout the Dominion averages 30 per cent greater than corresponding maximum available power figures calculated as in column 3. The figures quoted above, therefore, indicate that the *at present recorded water-power resources* of the Dominion will permit of a turbine installation of 41,700,000 *horse-power.* In other words, the present turbine installation represents only *6·6 per cent* of the present recorded water-power resources.

The above figures may be said to represent the *minimum water-power possibilities* of the Dominion. As illustrative of this the detailed analyses which have been made of the water-power resources of the provinces of New Brunswick and Nova Scotia have disclosed most advantageous reservoir facilities for regulating stream-flow and it is estimated that the two provinces possess within their respective borders 200,000 and 300,000 commercial horse-power. These figures provide for a diversity factor between installed power and consumers' demands.

AVAILABLE AND DEVELOPED TOTALS

The recorded power available throughout the Dominion, under conditions of ordinary minimum flow and within the limitations set out in the foregoing, is 18,255,000 horse-power. The water-power available under estimated flow for maximum development, i.e., dependable for at least six months of the year, is 32,076,000 horse-power. (For details see table 1).

There are installed to date throughout the Dominion water-wheels and turbines to the extent of 2,763,000 horse-power. However, it would not be correct to place this figure in direct comparison with the minimum or maximum available power figures quoted above and therefrom deduce the percentage of the available water-power resources developed to date. An allowance must be made for the average ratio between the water-wheels installed and the power available.

An analysis of the water-power plants scattered from coast to coast, concerning which complete information is available as to turbine installation and

satisfactory information as to stream flow, gives an average machine installation 30 per cent greater than the six months' flow maximum power. Applying this, the figures quoted above therefore indicate that the *at present recorded water-power resources* of the Dominion will permit of a turbine installation of 41,700,-000 horse-power. In other words the present turbine installation represents only *6·6 per cent* of the present recorded water-power resources.

DEVELOPED WATER-POWER IN CANADA

The 2,763,000 horse-power at present installed throughout the Dominion is apportioned to the following uses (see table 2):—

2,013,000 horse-power in central electric stations for general distribution purposes, such as operation of street railways, operation of mines, operation of electro-chemical and electro-metallurgical industries, operation of pulp and paper mills and for general industrial and domestic use.

476,000 horse-power installed in pulp and paper mills. In addition there is used in the pulp and paper industry 161,000 horse-power purchased from the central electric station installation.

274,000 horse-power installed in industries other than central electric stations and pulp and paper mills.

The total installation for the Dominion averages 315 horse-power per thousand population, a figure which places Canada second only to Norway in the per capita utilization of water-power among the countries of the world.

WATER-POWER IN THE CENTRAL STATION INDUSTRY

By far the most important use to which the development of water-power has been applied in Canada has been in connection with the central electric station industry. The extensive economic radius of modern electrical transmission, combined with the fortunate location of water-power in relation to centres of industry, has resulted in the widespread development of the Dominion's water-power resources through central electric stations. The extent of this industry and the important relationship which water-power bears to it may be measured by the fact that 91 per cent of the prime motive power is water-power and that there is now invested some $437,000,000 in hydro-electric plants and systems engaged in the production of electrical energy for sale and distribution.

Throughout the Dominion there are 282 hydro-electric stations with an installed turbine capacity of 2,013,000 horse-power or a generator installation of 1,701,000 k.v.a. (See table 3.) It is of interest to note that of the total turbine capacity, 1,449,000 horse-power is installed in commercial or privately owned stations while 564,000 horse-power is installed in municipal or publicly owned stations.

The units vary in size from 10-horsepower to the 55,000-horsepower turbines just installed in the Queenston development of the Ontario Hydro-Electric Power Commission and which are the largest water turbines anywhere installed at the date of writing. The turbine units in the industry average 3,077 horse-power, while the average installation of the central stations is 7,137 horse-power.

Continued and systematic progress is being made in the further development of the industry; new units are being installed, new plants constructed and new projects investigated having in view the necessity for meeting the growing domestic and industrial demand for cheap hydro-electric energy.

FUTURE GROWTH IN UTILIZATION OF WATER-POWER

It is profitable to consider the history of water-power utilization in Canada during the past few years in conjunction with the present activity with a view to making some reasonable forecast as to its probable future growth. (See Plate 1.) Should the rate of water-wheel installation during the past fifteen years be maintained, there will be installed in 1925, 3,360,000 horse-power; in 1930, 4,110,000; in 1935, 4,860,000 horse-power, and in 1940, 5,600,000 horse-power. In view of the increasing appreciation of the advantages of hydro-power combined with the fortunate location of ample supplies within easy transmission distance of practically every great industrial centre throughout the Dominion, there is every reason to anticipate that this rate of growth in utilization will be accelerated rather than retarded. Reference to the foregoing totals of water-power available will indicate that this anticipated increase in utilization will not seriously reduce the total reserves. Canada possesses sufficient reserves of water-power to meet all anticipated demands for many years to come.

In order to ensure the most beneficial utilization of these reserves and to provide intelligent guidance for their development, two essentials are required:—

1st. An accurate knowledge of the location, capacity and the engineering and economic possibilities of development of the water-powers throughout the Dominion, together with their relationship to other natural resources of mine and forest, to industrial centres and opportunities, to transportation systems—rail and navigation, to coal and fuel supplies, to irrigation, drainage and reclamation projects, to alternative sources of power and to market for and uses of power in general.

2nd. A sound governmental administrative policy designed to protect the public from inadvisable and ill-designed power schemes and to provide for reasonable regulation and revision of rates and rentals, and at the same time to ensure satisfactory guarantees for the encouragement of legitimate investment in hydro-power enterprises.

True conservation of our water-power resources, which are inexhaustible through use, lies, not in withholding them from development, but in their efficient utilization in the public interest for the economic exploitation of our other natural resources, and for the conservation of our exhaustible fuel supplies.

The water-power now developed in Canada represents an investment of $530,000,000. In 1940 should the rate of growth in installation during the past fifteen years be continued, this investment will have grown to over $1,000,000,000. The present development represents an annual equivalent of 20,500,000 tons of coal which, valued at $8 per ton, represents $164,000,000. In the year 1940 these annual figures will, with the foregoing assumption, have become 42,000,000 tons and $336,000,000. These figures are striking evidence of the outstanding importance and necessity of an intelligent administrative policy governing the development of our water-power resources.

TABLE 2.—DEVELOPED WATER-POWER IN CANADA—MARCH 1, 1922

Province	Turbine Installation in H. P.				
	In Central Stations	In Pulp and Paper Mills	In Other Industries	Total	Per 1,000 population
1	2	3	4	5	6
British Columbia	207,656	48,800	48,859	305,315	584
Alberta	32,380	....	807	33,187	57
Saskatchewan	....	....	....	....	....
Manitoba	93,355	....	10,792	104,147	170
Ontario	948,372	170,624	93,654	1,212,650	414
Quebec	696,593	224,412	94,380	1,015,385	432
New Brunswick	8,978	14,668	6,534	30,180	78
Nova Scotia	14,992	17,999	13,957	46,948	90
Prince Edward Island	245	....	1,624	1,869	21
Yukon	10,000	....	3,199	13,199	3,170
Canada	2,012,571	476,503	273,806	2,762,880	315

Column 2 includes only hydro-electric stations which develop power for sale.

Column 3 includes only water-power *actually developed* by pulp and paper companies. In addition to this total, pulp and paper companies purchase from the hydro-power central stations totalled in column 2, 72,122 h.p. in Ontario and 88,455 h.p. in Quebec. The total hydro-power utilized in the pulp and paper industry is therefore *637,080 h.p.*

Column 4 includes only water-power *actually developed* in connection with industries other than the central station and the pulp and paper industries. These industries also purchase blocks of power from the central stations totalled in column 2.

Column 5 totals all turbines and water-wheels installed in Canada.

Column 6 averages the Developed water-power per 1,000 population.

TABLE 3.—DEVELOPED WATER-POWER IN CANADA UTILIZED IN THE CENTRAL ELECTRIC STATION INDUSTRY—MARCH 1, 1922

Province	Commercial Stations			Municipal Stations			Total				
	No.	Installation		No.	Installation		No.	Installation			
		Generator K.V.A.	Turbine h.p.		Generator K.V.A.	Turbine h.p.		Generator K.V.A.	Horse-power per turbine unit	Horse-power per Station	Total Turbine h.p.
1	2	3	4	5	6	7	8	9	10	11	12
British Columbia	22	128,496	197,781	8	6,356	9,875	30	134,852	3,776	6,922	207,656
Alberta	3	22,250	32,380	...	...	...	3	22,250	10,793	2,491	32,380
Saskatchewan	...	...	...	...	...	...	...	...	...	...	...
Manitoba	3	11,063	26,255	1	57,000	67,100	4	68,063	4,913	23,339	93,355
Ontario	73	408,823	493,334	44	483,479	455,038	117	892,302	3,248	8,106	948,372
Quebec	80	546,316	678,778	15	13,238	17,815	95	559,554	3,210	7,333	696,593
New Brunswick	7	6,100	8,168	2	476	810	9	6,576	528	998	8,978
Nova Scotia	7	1,196	1,583	10	9,684	13,409	17	10,880	750	882	14,992
Prince Edward Island	6	307	245	...	245	245	6	307	35	41	245
Yukon	1	6,000	10,000	...	...	...	1	6,000	5,000	10,000	10,000
Canada	202	1,130,551	1,448,524	80	570,233	564,292	282	1,700,784	3,077	7,137	2,012,571

Commercial Stations include all privately owned.
Municipal Stations include all publically owned.
NOTE.—Statistics in this table are based upon a census of the industry made by the Dominion Bureau of Statistics in co-operation with the Dominion Water Power Branch.

Hydro-Electric Progress in Canada During the Past Year

During the year 1921 the readjustment of values following war time inflation made substantial progress. This readjustment necessarily brought in its train many business and financial difficulties and the lack of confidence in trading circles generally led to a reluctance of capital to embark upon new enterprises. Employment fell off with a corresponding diminution in popular purchasing power and in consequence there has been a general tendency to mark time while re-adjustment advances the further step which will bring costs within the reach of the normal spending power of the community both individual and corporate. The belief seems to be growing, however, that the nadir of depression has been passed and that business conditions are improving slowly but surely, and that though 1921 was a bad year for industry it also saw the turning point safely negotiated.

The hydro-electric industry though naturally affected by the general depression suffered no set-back and in fact the horse-power installed during 1921, 300,000 horse-power, stamps it as one of the most progressive years in Canadian water-power history.

The progress of development is somewhat difficult to follow from year to year because the year is too short an interval. From three to five years or even longer often elapses between the first consideration of development and the delivery of power. Again most projects commence with an initial installation much less than the ultimate projected capacity and new units of machinery are installed from time to time as the load develops. In other words, what we may call the scoring column often does not reflect new construction for some years after such construction has been actively under way, but continues to record new scores from old developments.

The 300,000-horsepower installation during 1921 is made up of both kinds of growth and in addition a considerable amount of new construction was initiated which ensures that as old power plants reach their ultimate capacity new ones will take their place in maintaining the continued growth and prosperity of Canadian hydro-electric enterprise.

That Canada is not lagging in water-power development may be shown by comparison with the country most comparable in general conditions, i.e., the United States, thus:—

—	H. P. installed per 1,000 of population		
	1902	1912	1920
Canada	47	198	280
United States	26	51	93

The total increase in horse-power installed in Canada from 1900 to 1920 was 153 per cent.

A brief review of development work in the individual provinces and of progress in investigation and plans will give a clearer view of the general situation. A summary will be found in table 4.

BRITISH COLUMBIA

The new construction work in British Columbia in 1921 included that of the British Columbia Electric Railway Company, which commenced the installation of a fourth unit of 13,200 horse-power at the Stave Falls plant and the Nanaimo Electric Light and Power Company, which placed in operation a 200-horsepower unit in its Coal Creek plant.

Surveys and investigatory work have been carried on for a development on Bridge river, 130 miles from Vancouver, where an ultimate development of 360,000 horse-power is available. The British Columbia and Alberta Power Company, Limited, has completed plans for the construction of a 6,000-horsepower plant on Bull river in 1922.

ALBERTA

In Alberta a development of 8,000 to 10,000 horse-power at Lake Minnewanka has been studied and surveyed to supplement the plants of the Calgary Power Company, as further power is urgently required in the city and district.

MANITOBA

In Manitoba the city of Winnipeg municipal plant at Pointe du Bois on the Winnipeg river was increased during 1921 by two units totalling 13,800 horsepower, and another unit of 6,900 horse-power is now being installed. This will bring the total installation up to eleven units aggregating 67,100 horse-power. A new duplicate transmission line to the city was also completed.

The development of Du Bonnet falls (Great falls) on the Winnipeg river, commenced in 1919 but delayed by financial conditions, is now financed and under active construction. The undertaking is taken over from the Winnipeg River Power Company by the Manitoba Power Company, Limited. The initial installation will be two units totalling 56,000 horse-power, and the ultimate, six units totalling 168,000 horse-power, at a cost of about $10,000,000; the initial installation is expected to be completed in 1924.

The city of Winnipeg and district will then be well supplied with power from the three developments, i.e., the city's plant, 67,100 horse-power, Winnipeg Electric Railway Company's plant at Pinawa, 35,600 horse-power, and the Du Bonnet plant 56,000 horse-power, a total of 160,700 horse-power; in addition to which the developments at Pointe du Bois and Du Bonnet provide for the installation of further units totalling some 146,500 horse-power. First-class undeveloped sites on the Winnipeg river will provide for approximately a further 300,000 installed horse-power, so that the total power available from this source is some 600,000 horse-power.

The Manitoba Power Commission, a provincial organization on similar lines to the Hydro-Electric Power Commission of Ontario, has been active during the past year in extending its transmission system and has now a considerable network. The original line to Portage la Prairie, conveying energy purchased in bulk from the city of Winnipeg, has been duplicated, and additional lines have been built to Morden, Carman, Roland, Jordan, etc. Extensions of 150 miles are contemplated during 1922.

ONTARIO

Construction in the province of Ontario during the past year has been very considerable. In the same period field investigations and activities leading to future construction have been extensive and there is good prospect of continued construction in the present year.

The Ontario Hydro-Electric Power Commission has continued its activity. Pre-eminent in its construction work of 1921 has been the *Queenston-Chippawa* project involving an initial installation of five 55,000-horsepower units and an ultimate installation of 600,000 horse-power. As is well known this development when completed will be the largest single hydro-electric plant in the world, containing the highest powered units (55,000 horse-power) yet built and setting in several respects new high standards in hydraulic practice. During the month of December water was turned on in the power canal and the first unit placed in operation. The second unit is ready for practically immediate operation. At

the *Cameron Falls* development on the Nipigon river for the supply of power to Fort William and Port Arthur, this being the second largest generating plant of the commission, construction of the control dam was completed, thereby permitting the initial installation of 25,000 horse-power operating under the full projected head. Provision has been made at the Cameron Falls plant for a total installation of 75,000-horsepower. Work on the 10,000-horsepower development at Ranney's falls on the Trent river near Campbellford was continued throughout the year.

Private interests have also been active in hydro-power construction. The Twin Falls plant, of the Abitibi Power and Paper Company with a capacity of 24,000 horse-power has been completed, while other new plants completed include the 5,200 horse-power development of the Spanish River Pulp and Paper Company at Smoky falls on the Sturgeon river and the 4,500-horsepower development of Canada Cottons Limited at Cornwall. Extensions to existing plants completed during the year include 7,200 horse-power at the plant of the Great Lakes Power Company at Sault Ste. Marie and 250 horse-power at the Lincoln Paper Mills plant at Merriton and an addition of 4,800 horse-power to the Kenora municipal plant is under construction.

The total turbine capacity installed in Ontario during 1921 amounted to 174,000 horse-power with provision made for extensive additions during the forthcoming year as market conditions demand.

Numerous water-power projects are receiving consideration. These have in view additional power supply for the Porcupine mining district; the electrification of the Timiskaming and Northern Ontario Railway, and various pulp and paper undertakings.

The proposals for the improvement of navigation and development of power on the St. Lawrence river have been far advanced during the past year. The Board of Engineers appointed by the International Joint Commission to examine the feasibility of the undertaking presented their report last July and this is understood to have been favourable from both the financial and engineering standpoints. In brief, this report suggested four schemes and recommended a combination plan by which the waterway improvement and initial power development of 1,464,000 horse-power, in the international section would cost $252,000,000 and estimated that the power development would pay for the entire project in a comparatively few years; the full potential power development is estimated at 4,100,000 horse-power which could be reached as the market for power developed. Alternative proposals have been submitted by the Hydro-Electric Power Commission of Ontario, by Hugh L. Cooper and Co., of New York, and by the New York and Ontario Power Company. The commission in a final report dated December 19, 1921, approve of the feasibility and desirability of the general navigation and power scheme but recommend that the engineering details be first passed upon by a joint board of engineers of the two Governments.

QUEBEC

The activities of the Hydraulic Service of the Department of Lands and Forests and of the Quebec Streams Commission acting for the Provincial Government, have proved a very real incentive to the increased utilization of the water-power resources of the province. Most beneficial work has been done by the Streams Commission in the actual creation of storage reservoirs in several of the principal watersheds. This work has not only proved of great value to the companies developing power on the various rivers so regulated but has also added considerably to the provincial revenues in that the cost is ultimately met by the companies benefited.

Recent operations of the commission have included the letting of the contract for a storage dam on the Savana river, a tributary of the Ste. Anne de Beaupre. This will provide additional water for the operation of the Laurentian Power Company's development at St. Fereol.

Considerable activity took place in water-power installation during the year 1921 throughout Quebec province. At Cedars, the Cedars Rapids Manufacturing and Power Company had under way the addition of two new units of 10,800 horse-power each, bringing their total installation to 151,200 horse-power. This company is also constructing a new transmission line of steel-cored aluminium cable, strung on steel poles, to Montreal, a distance of about 30 miles. At Shawinigan Falls, the Shawinigan Water and Power Company were preparing to install a new unit in their No. 2 power station of 43,000 horse-power. At Grand' mére additional turbine equipment was installed by the Laurentide Power Company to the extent of 42,000 horse-power. The city of Sherbrooke has reconstructed its hydro-electric plant at Weedon on the St. Francis river by increasing the head four feet and adding a new 1,700-horsepower unit bringing the total installation to 4,650 horse-power. At Nicolet falls on the Nicolet river the Lotbiniere Lumber Company placed in operation a new installation of 1,680 horse-power. The Dominion Textile Company replaced their old turbines at Magog by a new installation of 3,000 horse-power. At St. Raphael on the Riviere du Sud, La Corporation d'Energie de Montmagny placed in operation a new hydro-electric installation of 3,600 horse-power. Price Brothers and Co., Ltd., completed their hydro-electric development at Chute aux Galets on the Shipshaw river of 17,600 horse-power, the power to be transmitted for use in their pulp and paper mills at Kenogami and Jonquiere.

The development work completed in the province of Quebec during 1921 totalled to 90,000 installed horse-power, with 42,000 horse-power in process of installation. A number of new water-power developments were projected during the year.

NEW BRUNSWICK

In New Brunswick an active development policy is carried on by the province through the New Brunswick Electric Power Commission. Construction has proceeded on the development on the Musquash river, with an installation of 11,000 horse-power, for the supply of the cities of St. John and Moncton, and it is expected that power will be available for delivery in the spring of 1922. Contracts are now being negotiated for the annual supply of 15,000,000 kw.hrs. to St. John and 5,000,000 kw.hrs. to Moncton.

The Bathurst Lumber Company has had under construction at Grand falls on the Nepisiguit river a plant of 13,500 horse-power for the operation of their pulp and saw mills and the supply of all commercial needs of the district and the installation of 9,000 horse-power was completed during 1921. The New Brunswick Electric Power Commission have arranged for the purchase of a block of power from the plant and have completed a 33,000-volt transmission line 40 miles long connecting this development with Newcastle and other communities in that district.

The commission have in view a further development on the Lepreau river to supplement the supply to the cities of St. John, Moncton and districts, and a development on the Tetagouche river for the supply of the North Shore district.

NOVA SCOTIA

The Nova Scotia Power Commission, formed in 1919 under the "Power Commission Act" for the purpose of creating a complete electric power system for the province, has since pursued an enterprising development policy. The

first provincial development, that at St. Margaret Bay near Halifax, with an ultimate capacity of 15,000 horse-power is now ready to deliver some 6,600 horse-power (shortly to be increased to 10,800 horse-power) to Halifax as soon as the contract under negotiation with the city is completed. The reconstruction and enlargement of the 800-horsepower plant on Mushamush river for the supply of Mahone, Lunenburg, Riverport, etc., has been completed.

In addition to the above work of the commission several industrial installations have been made by private concerns. The Yarmouth Light and Power Company have practically completed the rebuilding of their plant destroyed by fire and an additional 150-horsepower unit is being installed at Messrs. Wright and Jodfrey's plant on the Gaspereau river.

Detailed investigations have been continued for a development with an ultimate capacity of 30,000 horse-power at Sheet Harbour to supply New Glasgow, Stellarton, Trenton, etc., and for two developments of 7,500 horse-power and 1,200 horse-power at Bear River, to supply Digby and other towns and projected industries.

TABLE 4.—WATER-WHEELS AND TURBINES INSTALLED IN 1921

Province	Turbine Installation in H. P.		
	On Jan. 1, 1921	Installed during 1921	On Jan. 1. 1922
1	2	3	4
British Columbia	305,115	200	305,315
Alberta	33,187	....	33,187
Saskatchewan	....	....	....
Manitoba	83,447	13,800	97,247
Ontario	1,039,000	173,650*	1,212,650
Quebec	926,095	89,290	1,015,385
New Brunswick	21,180	9,000	30,180
Nova Scotia	34,073	12,875	46,948
Prince Edward Island	1,869	....	1,869
Yukon and Northwest Territories	13,199	....	13,199
	2,457,165	298,815	2,755,980

*Includes two units in the Queenston Plant.

Water Power in the Pulp and Paper Industry in Canada

The manufacture of pulp and paper is one of Canada's outstanding industries and the normal progress during the past few years is an indication of the rapid expansion which may be expected in the future. According to the Bureau of Statistics figures for 1920 the pulp and paper industry in Canada represented a total capital investment of $347,553,333, found employment for 31,298 persons whose yearly wages and salaries amounted to $45,253,893, while the value of the products totalled $214,421,546. The export trade of $120 in 1890 for this industry is often contrasted with the present corresponding figure of over $100,000,000 to demonstrate the remarkable expansion during this period.

IMPORTANCE OF CHEAP POWER

The question of motive power in connection with the production of pulp and paper is a most vital one, and, in fact, is almost as important as that of raw material. In any industry the relative necessity of obtaining cheap and adequate power may be gauged by the amount required per dollar of product and with the possible exception of certain electro-chemical and metallurgical

processes, the requirements for pulp and paper are among the highest. The importance of cheap power may be judged from the fact that it takes practically 100 horse-power to make a ton of paper per day. It is, therefore, little surprising that motive power used in this industry is practically restricted to hydraulic energy and Canada's supremacy in the pulp and paper field rests on adequate and abundant water-powers well distributed among extensive forest resources.

A few general details are here given to show how this large amount of power is consumed in the operation of pulp and paper mills. (See also Plate 2.) Average figures in connection with a large Canadian mill show that mechanical pulp requires 73 horse-power per ton of daily output of which 67 horse-power is for grinding alone; sulphite pulp requires 8·7 horse-power per ton of daily output, and in other large mills as high as from 20 to 30 horse-power, while the production of newsprint from pulp consumes 12 horse-power for the same unit output. The continuous operation of mills in this industry, usually 24 hours per day, permits a very advantageous use of the necessary power and with direct water-power or hydro-electric energy further allows a cheap unit cost for the amount consumed. For instance, one Canadian sulphite mill with an installation of 1,500 horse-power, purchases hydro-electric power on the basis of $1 per horse-power per month plus a consumption charge on a sliding scale, and it was found that the minimum rate of 0·1 cent per kw.hr. could be taken advantage of for about 75 per cent of the total consumption, thus reducing their unit power cost very materially.

WATER POWER INSTALLATIONS FOR PULP AND PAPER INDUSTRY

In view of the very prominent place which the pulp and paper industry has acquired in Canada and further conscious of the important part which our water-power resources are playing in the development of this field, the Dominion Water-Power Branch recently undertook a special study in this connection and has gathered much information on power installation and requirements at pulp and paper mills operated by water-power or by purchased hydro-electric energy. The figures are complete to March, 1922. For the sake of brevity the general term "pulp and paper mills" has been adopted throughout this review and in the tables as including *pulp* mills, *pulp and paper* mills, and *paper* mills. The principal power and other features are presented in tabular form while the accompanying map (Plate 3) shows the location of the various mills listed.

The water-power installation for the operation of pulp and paper mills in Canada aggregates 476,503 horse-power, while the additional hydro-electric energy purchased for this industry is 160,577 horse-power, giving a total of 637,080 horse-power. This covers the energy derived directly or indirectly from water-power but does not include mills where steam only is used as motive power. The use of steam as a source of power in this industry is very limited and in most cases is prompted by special conditions such as operation in close connection with the manufacture of lumber when refuse from the latter can be used as fuel under the boilers. The census returns (1920) show a total steam-power installation in pulp and paper mills in the Dominion of only 62,400 horse-power, and if the capacity of the three or four larger steam operated mills where special conditions obtain is excluded, the remaining unit capacity works out to a very small amount.

The electric drive is an important consideration in this industry. Of the total water-power installation for the various mills a total of 178,911 horse-power is converted into electrical energy before it is used to operate the pulp and paper machinery. The advantages of electric drive are numerous; a uni-

Plate 2

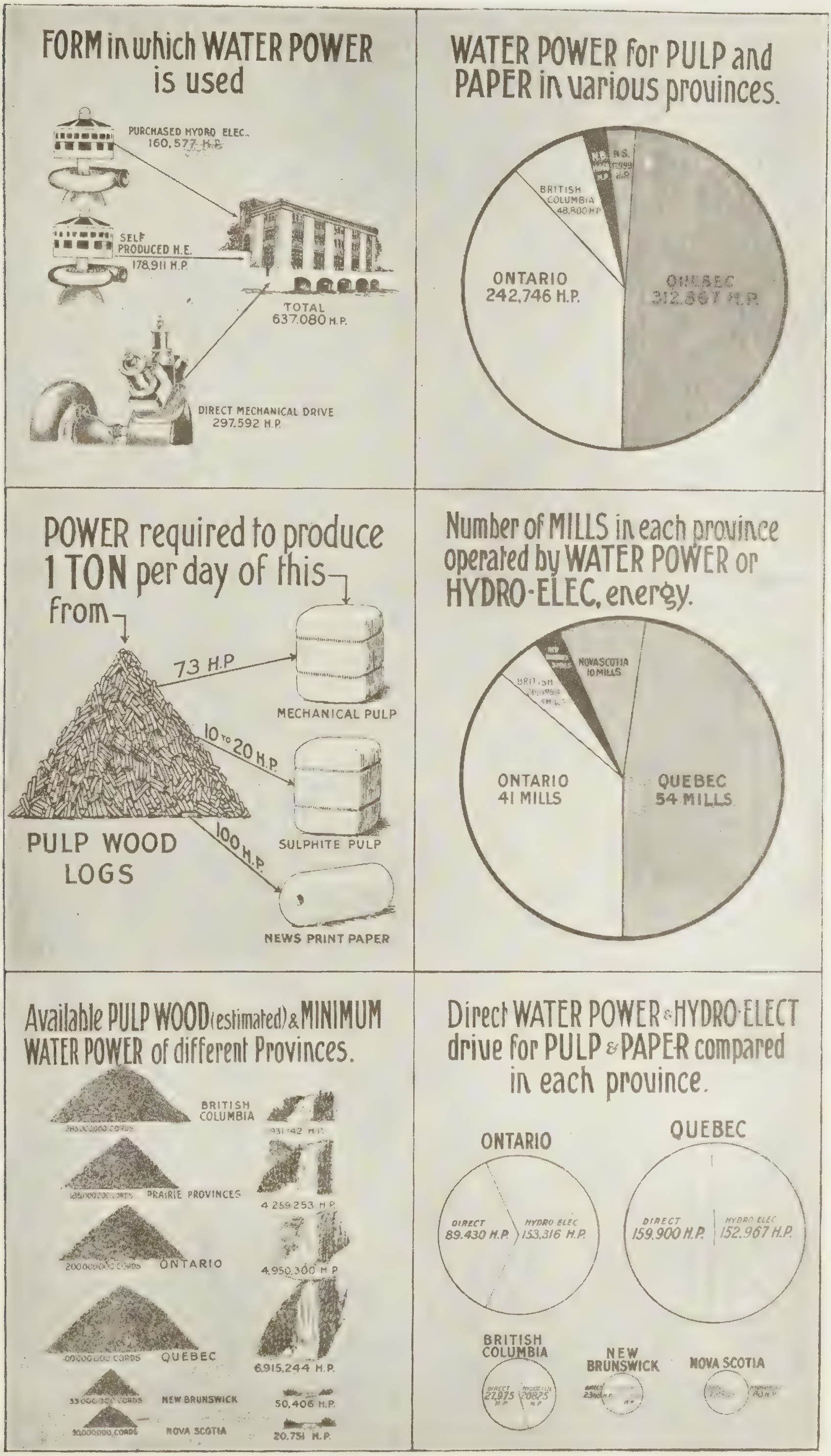
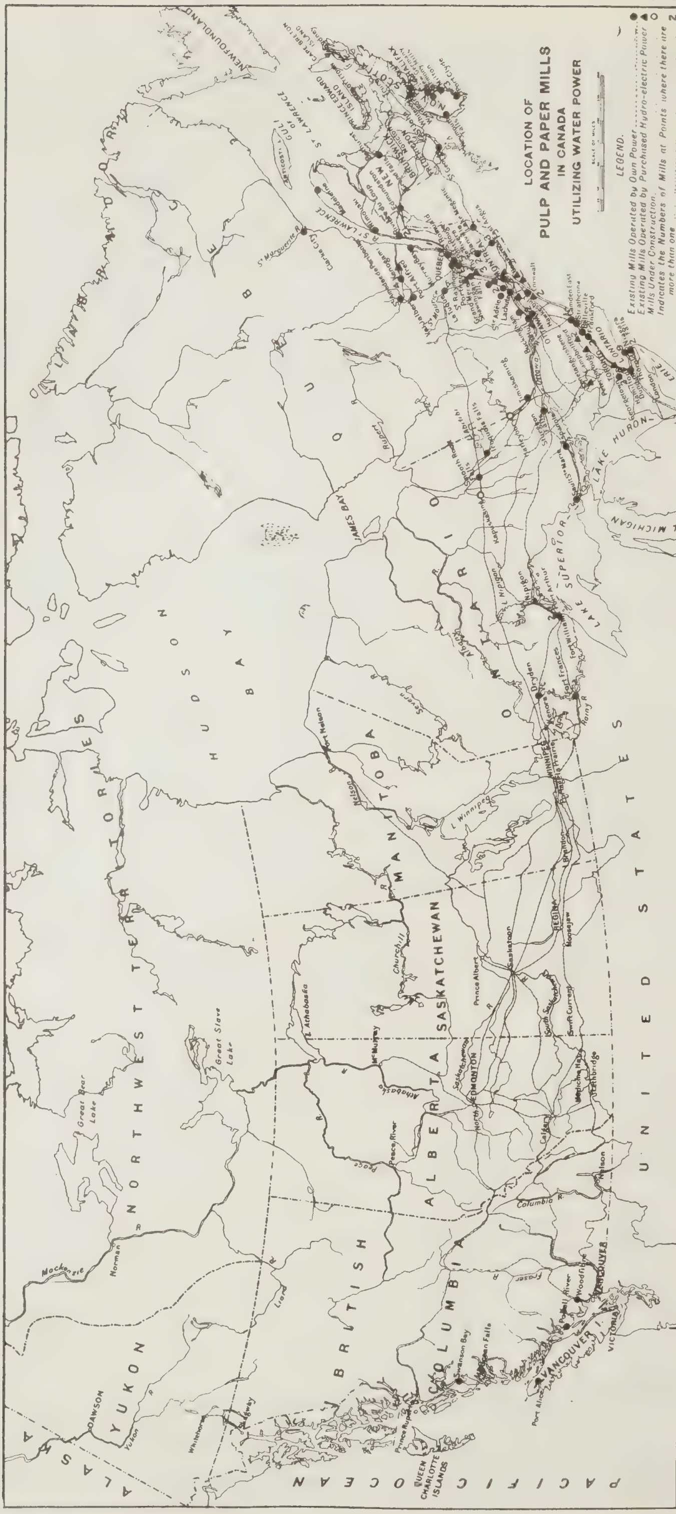

FORM in which WATER POWER is used
PURCHASED HYDRO ELEC. 160,577 H.P.
SELF PRODUCED H.E. 178,911 H.P.
TOTAL 637,080 H.P.
DIRECT MECHANICAL DRIVE 297,592 H.P.
WATER POWER for PULP and PAPER in various provinces.
BRITISH COLUMBIA 48,800 H.P.
N.S.
ONTARIO 242,746 H.P.
QUEBEC 312,867 H.P.
POWER required to produce 1 TON per day of this
from
73 H.P
MECHANICAL PULP
10 TO 20 H.P.
SULPHITE PULP
100 H.P.
PULP WOOD LOGS
NEWS PRINT PAPER
Number of MILLS in each province operated by WATER POWER or HYDRO-ELEC. energy.
NOVA SCOTIA 10 MILLS
ONTARIO 41 MILLS
QUEBEC 54 MILLS
Available PULP WOOD (estimated) & MINIMUM WATER POWER of different Provinces.
BRITISH COLUMBIA
PRAIRIE PROVINCES
4 259 253 H.P.
ONTARIO
4,950,300 H.P.
QUEBEC
6,915,244 H.P.
NEW BRUNSWICK
50,406 H.P.
30,000,000 CORDS
NOVA SCOTIA
20,751 H.P.
Direct WATER POWER & HYDRO-ELECT drive for PULP & PAPER compared in each province.
ONTARIO
DIRECT 89.430 H.P.
HYDRO ELEC 153,316 H.P.
QUEBEC
DIRECT 159,900 H.P.
HYDRO ELEC 152,967 H.P.
BRITISH COLUMBIA
DIRECT 27,975 H.P.
20875 H.P.
NEW BRUNSWICK
NOVA SCOTIA

PLATE 3


LOCATION OF
PULP AND PAPER MILLS
IN CANADA
UTILIZING WATER POWER
LEGEND.
Existing Mills Operated by Own Power
Existing Mills Operated by Purchased Hydro-electric Power
Mills Under Construction.
Indicates the Numbers of Mills at Points where there are more than one
HUDSON BAY
JAMES BAY
LAKE SUPERIOR
LAKE HURON
L. MICHIGAN
PACIFIC OCEAN
UNITED STATES
NORTHWEST TERRITORIES
YUKON
ALASKA
BRITISH COLUMBIA
ALBERTA
SASKATCHEWAN
MANITOBA
ONTARIO
QUEBEC
NEWFOUNDLAND
VANCOUVER I.
QUEEN CHARLOTTE ISLANDS
WINNIPEG
EDMONTON
VANCOUVER
VICTORIA
REGINA

form speed is assured which is of primary importance in governing the quality of the product; it also allows the centralized operation of a large mill receiving power from several hydro-electric sources while a closer study of power conditions, adjustment and consumption is permitted. A well known authority on pulp and paper mill operation in Canada recently stated that the proper way to build a paper mill was to develop the power as a hydro-electric project and locate the mill at a place most suitable from the operating and shipping point of view, adding that the time for direct-connecting of turbines to grinders was past.

WATER POWER INSTALLATION AT EACH MILL

Table No. 5 presents a complete list of pulp and paper mills in Canada operated by water-power, showing the principal features in connection with the motive power installation. A uniform index system for all water-power sites has been adopted throughout Canada and the first column gives the designation under this system of the particular water-power operating the mill referred to. Column 2 gives the name of the owner or company operating the mill, this being also accompanied by the head office address where latter is not at the mill; where no address is given under this column it may be taken as that given under column 4. The name of the river from which power is obtained is shown under column 3 while the head of water utilized in the development is given under column 5. The latter is often an important factor in the cost of power, a development under a high head being usually more economical. The number of turbine units installed to operate the mill and their total capacity, given in columns 6 and 7, bring out the principal points in connection with power requirements of the mill and give an idea of its importance while its efficient operation may also be judged from the average size of each turbine unit installed. A number of mills, while producing their own power, convert the whole or a portion of the latter to hydro-electric energy before using it throughout the mill; as this is an important feature in modern operation, mills where such conditions exist are marked (e). There are a number of cases where the hydro-electric power used at the mill is generated quite a distance from it, this practice being made possible through the ease with which the electric energy can be transmitted. In most instances, the pulp and paper mill is installed at a water-power site and when gradual expansion has necessitated additional motive power, another nearby hydraulic site has been developed and hydro-electric energy transmitted to the mill to permit centralized operation. In the lake St. John district in Quebec province one of the large mills receives energy from two hydro-electric plants located a few miles away and operated by the same company in addition to the water-power developed at the mill itself. In addition to the power produced for the particular purpose of operating the mill many pulp and paper organizations in Ontario and Quebec also purchase hydro-electric energy from outside sources and the installation given under column 8 does not represent the full capacity required; these mills are marked (p) in the last column of the table, to show that additional energy is purchased.

MILLS OPERATED FROM PURCHASED ENERGY

Table No. 6 gives a list of mills operated entirely from purchased hydro-electric energy, the special reference numbers given in the lrst column also corresponding to those on the accompanying map as in Table No. 5. Mills purchasing power and appearing in table No. 5 with the mark (p) have not been repeated in table No. 6. In this connection is may be mentioned that a few of the mills listed as purchasing power could practically be said to produce their own hydro-electric energy in cases where the power plant is almost

exclusively used to supply the pulp and paper mill but is operated by a subsidiary or allied organization. On the other hand we find large power organizations supplying a considerable amount of power to the pulp and paper industry. In Quebec, the Shawinigan Water and Power Company and allied organizations supply some 80,000 horse-power, while in Ontario, the Hydro-Electric Power Commission and Toronto Power Company together supply some 55,000 horse-power for this purpose.

CHARACTERISTICS OF GEOGRAPHIC GROUPS

The location of the pulp and paper mills in Canada shows that they are grouped according to facilities for wood, power or transportation. The various mills of the same group show certain outstanding features with regard to power requirements as a result of the class of production which characterizes the group.

Table No. 7 has been prepared to illustrate predominating features in certain districts into which our Canadian mills may be arbitrarily grouped. Perhaps the greatest contrast exhibited in this table is between the class of mills found in the Niagara and Toronto, Eastern Ontario, Montreal and Quebec city groups, where a large number of mills (column 2), whose average capacity is small (column 6), produce much of the miscellaneous kinds of paper (column 9), while the British Columbia and more northerly groups in Ontario and Quebec comprise mills of large capacity (column 6), requiring much power to produce principally pulp and newsprint (columns 7 and 8).

MOTIVE POWER BY PROVINCES

The mode of producing power for the operation of pulp and paper mills is summarized in table No. 8. While there is still a large amount of water-power used to drive the mill equipment directly from turbines, a considerable portion is utilized by first converting it to hydro-electric energy for the more convenient electric motor drive. Column 7 of this table which is made up by adding columns 4 and 6 gives the total hydro-electric energy, including that purchased from outside sources, and a comparison of these figures with those of column 3, representing direct drive from water-power, shows that the two modes of operation are fairly evenly divided in British Columbia and Quebec; that electric drive predominates in Ontario and New Brunswick, while direct water-power drive is used almost entirely in Nova Scotia.

GENERAL CONDITIONS IN EACH PROVINCE

A rapid inspection of the data in the various tables shows the province of Quebec slightly ahead of Ontario in the pulp and paper industry. British Columbia ranks next, followed by New Brunswick and Nova Scotia, while this industry has yet to be introduced into the Prairie Provinces.

Quebec.—This province has fifty-four mills, requiring a total of 312,867 horse-power either installed or purchased. The total daily producing capacity of these mills is some 3,000 tons of mechanical pulp, 1,500 tons of chemical pulp, 1,300 tons of newsprint, and 700 tons of other kinds of paper. There are naturally several large mills in this province where much energy is purchased or extensive water-power installations are required; the three largest are at Grand'Mère, where all the hydro-electric energy is purchased; Kenogami, where power is obtained from two hydro-electric plants in addition to that produced at the mill; Shawinigan, where a portion of the power is purchased; each of these mills require some 25,000 horse-power or more. Other large mills requiring between 10,000 and 25,000 horse-power include those at Hull, East Angus, Brompton, Chicoutimi, Clark City and Cap Magdeleine.

Ontario.—Ontario has 41 mills where the installed or purchased power aggregates 242,746 horse-power. These mills have a total daily producing capacity of some 2,000 tons of mechanical pulp, 1,100 tons of chemical pulp, 1,800 tons of newsprint, and 600 tons of other kinds of paper. The feature in this province is the Iroquois Falls mill requiring 52,000 horse-power including the energy transmitted from Twin falls; another large mill is located at Ottawa with an installation of 28,789 horse-power. Mills requiring between 10,000 and 20,000 horse-power are numerous and include those at Sault Ste. Marie, Espanola, Sturgeon Falls, Thorold, Fort Frances and Fort William.

British Columbia.—British Columbia has five mills operating by water-power but they are all of fair size and require a total installation of 48,800 horse-power while their daily producing capacity is 390 tons of mechanical and 345 tons of chemical pulp, 445 tons of newsprint and 30 tons of other kinds of paper. The two large mills at Powell River and Ocean Falls have respective installations of 24,000 horse-power and 20,550 horse-power.

New Brunswick.—This province only has three mills operated by water-power with a total installation of 14,668 horse-power and a daily producing capacity of 30 tons of mechanical and 250 tons of chemical pulp.

Nova Scotia.—There are ten mills operated by water-power in this province but most of them are not large; their total installation aggregates 17,999 horse-power and their daily producing capacity is some 230 tons of mechanical pulp.

FUTURE POWER REQUIREMENTS OF INDUSTRY

A few words may be added regarding the future trend of the pulp and paper industry which should be of particular interest from a water-power point of view. Owing to the present financial depression no very great expansion need be immediately expected. A very realistic illustration of what should be expected when industrial conditions become normal was afforded by the pulp and paper boom of 1918 and 1919. A large number of projected undertakings were then investigated and many requests for information were received by Dominion Government organizations in possession of the desired data, as in most cases the parties concerned did not care in what province the mills were to be established. It was a case of obtaining pulp wood and water-power almost at any cost and anywhere within reason. While most of these projects did not materialize owing to subsequent financial and other conditions they revealed what conditions may be expected in the future development of the industry and demonstrated what an important part our northern water-powers will be called upon to assume in this connection.

It has recently been estimated that the present pulp wood demands on our forests consume some 20,000 acres per year and following the trend of other commodities this consumption will most probably assume a rapidly increasing rate. While the reforestation methods now being extensively introduced will later on help to remedy this depletion, it must be noted that a period of from 50 to 100 years is required for suitable growth, and until full results are realized it will doubtless be necessary to extend wood pulp operations farther and farther north and the bountiful supply of water power located in these regions will in no small degree facilitate the fullest development of this industry. Pulp wood and water-power are the chief factors in connection with future expansion, and Table No. 5 shows side by side the proportion of these resources available in each province of the Dominion.

TABLE NO. 5.—PULP AND PAPER MILLS IN CANADA OPERATED BY WATER POWER—MARCH 1, 1922

BRITISH COLUMBIA

Index No.	Owner or Company	Plant or Mill			Turbine Installation		Foot Notes
		River	Location	Head in feet	No. of units	Total H.P.	
1	2	3	4	5	6	7	8
$8FD_1$...	Pacific Mills, Vancouver.........	Link............	Ocean Falls.....	140	12	20,550	*e*
$8FD_5$...	....	Swanson cr......	1 mile from Swanson bay.	130	4	1,750	*e*
$8GA_4$...	Whalen Pulp and Paper Mills, Ltd., 650 Pender St. W., Vancouver.	Mill cr. and	Woodfibre......	580	3	1,250	*e*
		Cedar cr.	"	1,100		950	
$8HE_3$...	....	Victoria lake...	Port Alice......	400	1	300	*e*
$8GB_1$...	Powell R. Co., Ltd., Vancouver..	Powell..........	Powell..........	147	7	24,000	*e*
	Total..................	....	....	......	......	48,800	

ONTARIO

Index No.	Owner or Company	River	Location	Head in feet	No. of units	Total H.P.	Foot Notes
$5PC_1$...	Fort Frances Pulp and Paper Co., Limited.	Rainy..........	Fort Frances....	28	9	18,000	*e, b*
$5QD_1$...	Dryden Pulp and Paper Co., Ltd.	Wabigoon.......	Dryden.........	45	2	1,800	*e*
....	The Spruce Falls Co............	Kapuskasing....	Kapuskasing....	......	......	....	*a*
$4LB_1$...	Mattagami Pulp and Paper Co.,	Mattagami.....	Smooth Rock Falls.	36	3	9,350	*e*
$4MC_1$...	Abitibi Power and Paper Co., Ltd., Montreal.	Abitibi.........	Iroquois Falls..	41·5	14	28,000	*e*
$4MC_2$...		"	Twin Falls......	60	4	24,000	*e*
$2CA_2$...	Spanish River Pulp and Paper Mills, Ltd., Toronto.	St. Marys......	Sault Ste. Marie	18	12	14,400	
$2CE_3$...	" "	Spanish.........	Espanola........	63	8	15,820	*e*
$2DC_1$...	" "	Sturgeon........	Sturgeon Falls..	36	11	13,390	*e*
$2DC_2$...	" "	"	10 miles north of Sturgeon Falls.	35	2	5,200	*e*
$2HB_4$...	Provincial Paper Mills, Toronto..	Credit R........	Georgetown....	12	1	65	*p*
$2HB_{21}$..	" " ..	Credit R........	"	21	2	150	*e, p*
$2HB_{28}$..	John Fisher & Son, Ltd..........	Morden's cr.....	Dundas.........	42	2	312	
$2HA_7$...	Garden City Paper Mills, Ltd....	Old Welland Canal.	St. Catharines..	12	2	285	
$2HA_8$...	Kinleith Paper Mills, Ltd........	" "	" ..	21	2	605	*p*
$2HA_{10}$..	Lincoln Paper Mills..............	" "	Merritton.......	18	4	639	
$2HA_{32}$..	" "	" "	"	25	3	1,450	*e*
$2HA_{15}$..	Riordon Co., Ltd................	" "	"	14	3	650	*e, p*
$2HA_9$...	Provincial Paper Mills, Toronto..	" "	Thorold........	14	2	1,040	*e*
$2HA_{23}$..	" " ..	" "	"	12	3	453	
$2HA_{11}$..	Beaver Wood Fibre Co., Ltd.....	Welland Canal..	"	22	2	680	*p*
$2HA_{12}$..	Thorold Pulp Co.................	Old Welland Canal.	"	12	5	614	
$2HK_6$..	Canadian Paperboards Co., Ltd., Montreal, P.Q.	Trent...........	Frankford......	13	5	1,080	*e, p*
$2HK_{12}$..	Miller Bros. Co., Ltd., Montreal.	"	4 miles from Trenton.	11	4	684	*e*
$2HL_1$...	Belleville Paper Mills, Ltd.......	Moira...........	Belleville.......	14	2	90	*p*
$2HM_4$...	Strathcona Paper Co.............	Napanee........	Strathcona......	8	2	153	*p*
$2HM_{25}$..	Specialty Paper Mills............	"	Camden East...	18	1	125	
$2LA_{12}$...	The Bronson Co..................	Ottawa.........	Ottawa.........	29	1	2,000	
$2LA_{13}$...	J. R. Booth, Ltd................	"	"	30	13	28,789	*e*
$2MC_{11}$..	Howard Smith Paper Mills, Montreal, P.Q.	Cornwall canal.	Cornwall........	8	13	800	*e, p*
	Total..................	....	....	......	......	170,624	

(*a*) Under construction.
(*b*) Portion of power is exported to U.S.
(*e*) All or portion of power converted to hydro-electric energy.
(*p*) Hydro-electric energy is also purchased from an outside source.

TABLE No. 5.—PULP AND PAPER MILLS IN CANADA OPERATED BY WATER POWER—MARCH 1, 1922—*Con.*

QUEBEC

Index No.	Owner or Company	Plant or Mill			Turbine Installation		Foot Notes
		River	Location	Head in feet	No. of units	Total H.P.	
1	2	3	4	5	6	7	8
2JE₅	Riordon Co., Ltd	Gordon cr	Timiskaming	214	2	7,200	*e*
2LA₁₁	E. B. Eddy Co., Ltd	Ottawa	Hull	34	7	14,149	*e*
2LF₂	Jas. MacLaren Co., Ltd	Lievre	Buckingham	45	8	8,125	
2LC₁₃	J. C. Wilson, Ltd	North	Lachute	18	9	1,200	
2LC₁₀	Rolland Paper Co., Ltd	"	St. Jerome	25	4	800	*e*
2LC₃₆	J. C. Wilson, Ltd., Montreal	"	"	33	......	954	
2LC₁₁	Rolland Paper Co., Ltd	"	Ste. Adele	100	5	1,325	
2MC	Howard Smith Paper Mills, Ltd., Montreal.		Beauharnois	......	......	300	*p*
2OA₃	Canadian Paperboard Co	Lachine canal	Montreal	9	2	180	*e, p*
2OA	J. R. Walker and Co., Ltd., Montreal.	Ottawa	Sault au Recollet.	7	......	850	
2OE₃₃	Howard Smith Paper Mills, Ltd., Montreal.	Lac Ouareau	Crabtree Mills	29	1	1,200	*e*
2OB₄	Alex. McArthur & Co., Ltd., Montreal.	L'Assomption	Joliette	12	3	275	*p*
2NG₁₁	Belgian Industrial Co., Ltd	St. Maurice	Shawinigan F.	140	20	17,910	*p*
2NE₁	Brown Corporation, Portland, Me.	"	La Tuque	85	2	3,200	*e*
2OD₂	Dominion Paper Co., Montreal	Nicolet	Kingsey Falls	24	3	880	*e*
2OD₂₂	Lotbiniere Lumber Co	"	Danville	57	5	1,680	*e, p*
2OE₁₃	Brompton Pulp and Paper Co., Montreal.	St. Francois	East Angus	55	13	10,701	*p*
2OF₁₁	" "	"	Bromptonville	30	9	10,316	*e*
2OF₄	Canada Paper Co., Ltd., Montreal.	"	Windsor Mills	15	15	5,025	*p*
2PJ₁₃	Lake Megantic Pulp Co	Chaudiere	Lake Megantic	20	5	1,550	
2PC₁	Rowland Ford and Son	Portneuf	Portneuf	22	3	450	*e*
2PC	Ru-Ber-Oid Felt Mfg. Co., Ltd., Montreal.	"	"	......	......	750	
2PC₁₆	Montreal Paper, Ltd	"	Portneuf Stn	18	......	250	*p*
2PC	Joseph Ford and Co	"	" (No. 1 Mill)	8			
2PC	" " "	"	Portneuf Stn. (No. 2 Mill)	15	......	250	*p*
2PC₆	Eastern Paper Co., Ltd	"	St. Basile	13	2	130	
2PC₁₀	Joseph Piche	"	"	8	1	75	
2PB₃	News Pulp and Paper Co., Ltd., Montreal.	Ste. Anne	St. Raymond	31	10	4,080	*e*
2PC₇	Donnacona Paper Co., Ltd., Donnacona.	Jacques Cartier	Pont Rouge	65	1	1,000	
2PC₂₁	Bird and Son, Ltd., Hamilton, Ont.	"	"	17	7	1,384	*e*
2PC₂	Donnacona Paper Co., Ltd	"	Donnacona	60	5	6,000	*e, p*
2PH₁₅	Henry Atkinson, Registered	Etchemin	St. Romuald	26	4	946	*e*
2PH₂₆	" "	"	"	10	4	167	
2PE	Richard and Co., Quebec	Petit Pre	L'Ange Gardien.	600	......	500	
2RG₇	La Cie de Pulpe de Chicoutimi, Chicoutimi.	Ouiatchouan	Val Jalbert	254	4	7,300	
2RC₂	Quebec and Saguenay Pulp Co.	Little Peribonka.	St. Amedee de Peribonka.	22	5	1,500	*e*
2RH₉	Jonquiere Pulp Co., Quebec	Au Sable	Jonquiere	65	3	4,500	
2RH₁₃	Price Bros. and Co., Ltd., Quebec	"	Kenogami	265	8	26,200	*e*
2RH₁₄	" "	Shipshaw	Ste. Anne de Chicoutimi.	90	3	10,600	*c, e*
2RH₁₇	" "	"	Chute aux Galets.	101	2	17,600	*c, e*

(*c*) Hydro-electric plants supplying Kenogami and Jonquiere mills.
(*e*) All or portion of power converted to hydro-electric energy.
(*p*) Hydro-electric energy is also purchased from an outside source.

TABLE No. 5.—PULP AND PAPER MILLS IN CANADA OPERATED BY WATER POWER—MARCH 1, 1922—*Con.*

QUEBEC—*Con.*

Index No.	Owner or Company	Plant or Mill					Foot Notes
		River	Location	Head in feet	Turbine Installation		
					No. of units	Total H.P.	
1	2	3	4	5	6	7	8
2RH$_4$...	La Cie de Pulpe de Chicoutimi, Chicoutimi.	Chicoutimi.....	Chicoutimi.....	105	6	10,850	*p*
2RH$_8$...	" "	"	"	85	6	9,350	*p*
2PF$_2$....	Donahue Bros., Reg'd...........	Murray Bay....	Murray Bay....	58	5	9,000	*e*
2PG$_3$...	Wolf River Pulp and Paper Co...	Riviere du Loup	Riviere du Loup	75	3	3,160	
2PG$_4$...	F. Flo Soucy....................	"	Old lake road...	40	2	800	
2QA$_3$...	Price-Porritt Pulp and Paper Co., Que.	Rimouski.......	Rimouski.......	52	2	3,150	*e*
2UB$_1$...	Gulf Pulp and Paper Co..........	Marguerite......	Clark City......	54	7	11,000	*e*
2QC$_3$...	Great Eastern Paper Co., Montreal.	Madeleine.......	Madeleine.......	102 22	2	5,600	*e*
	Total....................	....	....	......	......	224,412	

NEW BRUNSWICK

Index No.	Owner or Company	River	Location	Head in feet	No. of units	Total H.P.	Foot Notes
1AD$_1$...	Fraser Companies, Ltd...........	Madawaska.....	Edmundston....	24	2	3,000	*e*
1BK$_1$...	Bathurst Co., Ltd., Bathurst....	Nipisiguit......	Grand Falls....	110	2	9,000	*e*
1AQ$_1$...	St. George Pulp and Paper Co., South Norwalk.	Magaguadavic..	St. George......	46	4	2,668	*e*
	Total....................	....	....	......	......	14,668	

NOVA SCOTIA

Index No.	Owner or Company	River	Location	Head in feet	No. of units	Total H.P.	Foot Notes
1DB$_2$...	Sissiboo Pulp and Paper Co., Ltd. Weymouth.	Sissiboo........	Weymouth Falls.	60	4	3,120	*e*
1EB$_5$...	Clyde Pulp Co., Halifax..........	Clyde..........	Port Clyde.....	20	4	1,800	*e*
1ED$_2$...	MacLeod Pulp and Paper Co., Ltd., Liverpool.	Mersey.........	Rapid Falls.....	33	14	6,024	
1ED$_3$...	" "	"	Cowie Falls.....	22			
1EE$_{11}$..	Panstock Corporation............	Medway........	Harmony Mills.	38	2	2,250	*e*
1EE$_3$...	Nova Scotia Wood Pulp and Paper Co., Ltd., Charleston.	"	Mill Village.....	18	3	1,625	
1EF$_1$...	La Have Pulp Co., Ltd., New Haven, Conn.	La Have........	New Germany..	30	6	1,500	
1DD$_{15}$..	Gaspereau River Light, Heat and Power Co., Wolfville.	Gaspereau......	Whiterock......	30	1	580	
1DE$_3$...	St. Croix Paper Co., Ltd., Halifax	St. Croix........	Hartville.......	28	3	100	
1DE$_4$...	Panuke Pulp and Paper Co., Ltd., Windsor.	"	"	27	3	1,000	
	Total....................	....	....	......	......	17,999	
	Canada..................	....	....	......	......	476,503	

(*e*) All or portion of power converted to hydro-electric energy.
(*p*) Hydro-electric energy is also purchased from an outside source.

TABLE No. 6.—PULP AND PAPER MILLS IN CANADA OPERATING ENTIRELY FROM PURCHASED HYDRO-ELECTRIC POWER—MARCH 1, 1922

ONTARIO

Company or Owner	Head Office	Location of Plant	Power Purchased From
Fort William Paper Co., Ltd.....	Fort William, Ont..	Fort William, Ont	Kaministiquia Power Co.
Provincial Paper Mills, Ltd.......	56 University Ave., Toronto, Ont.	Port Arthur.......	Hydro-Electric Power Comm.
Nipigon Fibre and Paper Mills, Limited.	Nipigon, Ont........	Nipigon...........	" " "
(a) Timiskaming Pulp and Paper Co.	Haileybury, Ont....	Haileybury.......	Northern Ontario Light and Power Co.
Fibre Board.....................	Penetanguishene....	Penetanguishene..	Hydro-Electric Power Comm.
Interlake Tissue Mills, Ltd.......	Merritton...........	Merritton.........	" " "
Ontario Paper Co., Ltd...........	Thorold............	Thorold..........	Toronto Power Company and Hydro-Electric Power Com.
Hinde and Dauch Paper Co. of Canada, Ltd.	43 Hanna Ave., Toronto.	Toronto...........	Hydro-Electric Power Comm.
Don Valley Paper Co., Ltd......	714 Dominion Bank Bldg., Toronto.	Don Valley, Toronto.	Toronto Power Co.
Canadian Nashua Paper Co., Ltd.	Peterborough, Ont.	Peterborough.....	Hydro-Electric Power Comm.
Canadian Paperboard Co., Ltd..	2 Seigneur St., Montreal, P.Q.	Campbellford.....	Town of Campbellford.
Hydro-Electric Power Com. of Ontario.	Toronto, Ont.	"	Hydro-Electric Power Comm.
Provincial Paper Mills, Ltd.......	56 University Ave., Toronto, Ont.	Mille Roches......	St. Lawrence Power Co.
Cornwall Pulp and Paper Co. Ltd.	Cornwall, Ont.......	Cornwall..........	Hydro-Electric Power Comm. and St. Lawrence Power Co. Ltd.
Riordon Company, Ltd..........	355 Beaver Hall Sq., Montreal, P.Q.	Hawkesbury......	Hawkesbury Electric Light and Power Company..

QUEBEC

Company or Owner	Head Office	Location of Plant	Power Purchased From
The Beaver Company Ltd.......	Buffalo, N.Y.......	Aylmer Road.....	Hull Electric Co. Ltd.
Valleyfield Coated Paper Mills, Ltd.	Valleyfield..........	Valleyfield........	Valleyfield Electric Co.
Bennett Limited.................	Chambly Canton...	Chambly Canton.	Montreal Light, Heat and Power Consolidated.
International Paper Co...........	30 Broad St., New York City.	Three Rivers.....	Shawinigan Water and Power Co.
Wayagamack Pulp and Paper Co., Limited.	Three Rivers........	Three Rivers.....	" " "
St. Maurice Paper Co., Ltd.......	Board of Trade Bldg., Montreal, P.Q.	Cap Magdelaine...	" " "
Laurentide Company, Ltd........	Grand'mère.........	Grand'mère.......	Laurentide Power Co. Ltd.
The Ha Ha Bay Sulphite Co., Limited.	Port Alfred.........	Port Alfred.......	La Soc. d'Eclairage et d'Energie Electrique du Saguenay.

(*a*) Under construction.

Table No. 7.—Hydraulic Power in Pulp and Paper Mills—Characteristics of Various Groups —March 1, 1922

Groups	Number of mills in group	Power-H. P.				Average Daily Producing Capacity per Mill in Group—Tons		
		Own turbine installation	Purchased Hydro-Electric	Total for group	Total per mill in group	Pulp	Paper	
							News	Other
1	2	3	4	5	6	7	8	9
British Columbia	5	48,800	....	48,800	9,760	147	89	6
North and Western Ontario	7	81,150	16,350	97,500	13,930	173	93	4
North Lake Huron	3	48,810	....	48,810	16,270	268	223	....
Niagara and Toronto District	17	6,943	42,142	49,085	2,890	33	18	18
Eastern Ontario	14	33,721	13,630	47,351	3,380	42	12	17
Montreal District and Western Quebec.	15	36,558	3,345	39,903	2,660	28	5	17
Eastern Townships	6	30,152	8,500	38,652	6,440	90	18	24
St. Maurice Valley and Three Rivers district.	6	21,110	66,350	87,460	14,570	268	111	27
Quebec City district	14	15,982	3,760	19,742	1,410	15	10	7
Lake St. John and Saguenay district.	7	87,900	6,500	94,400	13,490	176	44	5
Lower St. Lawrence and Gulf	6	32,710	....	32,710	5,450	72	....	....
New Brunswick	3	14,668	....	14,668	4,890	93	....	....
Nova Scotia	10	17,999	....	17,999	1,800	23	....	....

Note.—The large capacity of mills predominating in certain districts is emphasized by the figures under column 6, while the class of production characterising each group can be judged by the figures under columns 7, 8 and 9.

Table No. 8.—Developed Water-Power in Canada Utilized in the Pulp and Paper Industry—March 1, 1922

Province	No. of mills	Installed and Purchased Power—H. P.					
		Turbine Installation in the Industry			Purchased Hydro-Electric power	Total Hydro-Electric cols. 4 and 6	Total from all sources cols. 5 and 6
		Direct drive	Hydro-Electric drive	Total			
1	2	3	4	5	6	7	8
British Columbia	5	27,975	20,825	48,800	....	20,825	48,800
Ontario	41	89,430	81,194	170,624	72,122	153,316	242,746
Quebec	54	159,900	64,512	224,412	88,455	152,967	312,867
New Brunswick	3	2,368	12,300	14,668	....	12,300	14,668
Nova Scotia	10	17,919	80	17,999	....	80	17,999
Canada	113	297,592	178,911	476,503	160,577	339,488	637,080

Column 3 represents the installation which is used to drive the mill machinery, such as grinders, etc., directly from water-power.

Column 4 represents the installation also operated by pulp and paper organizations but where the power is first converted into hydro-electric energy and electric drive is used to operate all or a portion of the mill.

Column 5 is made up by adding columns 3 and 4 and represents the total water-power installation operated by the pulp and paper organizations themselves.

Column 6 represents the amount of electric energy derived from water-power and purchased from central electric stations for use in the pulp and paper industry.

Column 7 is made up by adding columns 4 and 6 and indicates the use of electrical energy derived from water-power in the pulp and paper industry.

Column 8 gives the totals of columns 5 and 6 and indicates the total installation and purchased power for the industry derived directly or indirectly from water-power.

Table No. 9.—Available Pulp Wood and Water Power of Canada

Province	Estimated pulp wood resources million cords	*Available water-power at ordinary minimum flow—h.p.
British Columbia	285	1,931,142
Prairie provinces	185	4,259,253
Ontario	200	4,950,300
Quebec	300	6,915,244
New Brunswick	33	50,406
Nova Scotia	30	20,751

*See footnote under table 1.

The Central Electric Station Industry of Canada

Despite the widespread financial and industrial depression which has operated to retard or prohibit expansion in almost every other line of endeavour there has been a steadily increasing and healthy growth in the central electric station industry. An indication of the anticipated revival of general industry with its consequent greater demand for power may be seen in the renewed activities of those larger central electric station organizations whose load is mainly dependent on the extent of the operations of the manufacturing companies in the industrial districts over which their power service extends.

In addition to the renewed demands for power on the part of manufacturers who have been operating their plants on a restricted basis because of the general slackness in trade, there are three other classes of business whose requirements must be met. The first is that of the steadily increasing number of manufacturers who have in the past depended upon coal as a source of power but who, finding that the regular annual increase in the price of that commodity militates against successful competition with other firms, are changing their equipment to make use of the more economical, elastic and efficient electric drive. The second is the large number of new manufacturing concerns who are providing for the power requirements of their establishments by installing electric motors, while the third is the rapidly developing electro-chemical industry in its various phases.

The amount of current sold ostensibly for lighting is also increasing rapidly due largely to the general utilization of the various electrical aids to housekeeping, such as electric ranges, water heaters and grates, individual water systems, washing machines, vacuum cleaners, toasters, etc.

Under the terms of the co-operative agreement existing between the Dominion Water Power Branch and the Dominion Bureau of Statistics and in connection with the census of industry conducted by the bureau, a census of the central electric station industry of Canada is taken annually, the statistics resulting therefrom being presented to the public through the medium of the annual reports of the Census Bureau.

At longer intervals, depending on the varying condition of the industry, a complete directory showing the investment in plant and equipment, installation, mechanical equipment, service, power for sale, rates and transportation facilities of the individual central electric stations dealt with collectively in the statistical reports of the Census Bureau is compiled and issued by the Dominion Water Power Branch.

The rapid development of the industry since the issuing of the first directory in 1919, the exhaustion of the edition and the persistent demand for copies

thereof having combined to emphasize the necessity of a new directory, the compilation of the same was put in hand late in the year and has since been progressing steadily. While much of the data included in the directory is based on the statistics obtained through the annual census, it has been possible through the generous co-operation of the various organizations listed to include considerable later information. The new directory will be issued as Water Resources Paper No. 33.

During the past year the fourth census of the central electric station industry conducted in accordance with the co-operative agreement referred to above was taken and an analysis of the statistics showing the conditions obtaining as at January 1, 1921, is now possible.

An interesting summary of the principal items of interest as affecting the Dominion and each of the provinces, is given in Table 10. Of the 819 stations reported 506 or 61·8 per cent operate sufficient generating equipment to not only supply their own regular distribution but also to provide for the demands of the remaining 313 or 38.2 per cent which do not themselves generate electricity. Among the provinces, Ontario is seen to have made the greatest progress in the generation of electricity, leading in every class of station, in investment, revenue, installation and per capita consumption of energy.

CAPITAL INVESTED AND REVENUE

The total capital invested in the industry amounts to $448,273,642 of which $391,491,682 or 87·4 per cent represents the cost of actual development and distribution, including as it does $162,582,537 invested in lands, buildings and fixtures, $148,821,478 the value of the mechanical equipment in generating, receiving and transforming stations, and $80,087,667 the value of the transmission and distribution systems. Of the remainder of the capital, $9,630,092 is invested in materials on hand, fuel and miscellaneous supplies, while cash on hand, trading and operating accounts and bills receivable amount to $47,151,868.

The gross revenue from the sale of power amounts to $65,705,060. Against this, however, must be offset expenses totalling $45,100,946, made up of salaries and wages, $14,626,709, fuel costing $3,190,216 and miscellaneous expenses of $27,284,021.

ELECTRICAL ENERGY GENERATED

The total output of electricity generated by the stations reporting amounted to 5,894,867,000 kw. hrs. The capacity of the generators installed in the stations reporting this output totalled to 1,471,369 kv.a. indicating an operating load factor of only 45.6 per cent and emphasizing the great value of the industry of the introduction of any apparatus which will provide a market capable of absorbing off-peak power at reasonable rates.

PRIMARY POWER EQUIPMENT

The aggregate installed capacity of all types of prime-movers in central electric stations in Canada is 2,033,616 horse-power, of which 1,897,024 horse-power represents main plant installation and 136,592 horse-power is fuel auxiliary or stand-by equipment used to supplement the output of the hydro-electric stations in periods of excessive demand or shortage of power due to accidents, insufficient water or similar causes. The main plant equipment is made up of water-wheels and turbines having a combined capacity of 1,754,130 horse-power, steam reciprocating engines and steam turbines totalling 266,551 horse-power, and gas and oil engines 12,935 horse-power.

HYDRO-POWER VS. FUEL POWER IN CENTRAL ELECTRIC STATIONS

In any country the utilization of an inexhaustible resource such as water-power, as compared with an exhaustible one such as a coal or oil fuel supply, is of prime importance. In a country of such area that its main industrial centres are at considerable distances from coal fields the wide distribution of readily developed water-power is a foremost agency in permitting those industries to keep pace with outside competition.

Canada is particularly favoured in regard to having her water-powers advantageously located for development and the extent to which this advantage has been seized may be realized when it is stated that the per capita water-wheel installation in Canada exceeds that of the United States by about 285 per cent.

In table 11 is presented a comparison according to the source of primary power used, of the leading features of the central electric station industry, which shows the great preponderance attained by water-power in this industry. In this table the term hydraulic stations includes all hydro-generating stations and all non-generating stations distributing hydraulically generated electric power, a similar convention being followed in regard to the term fuel stations.

While of the 819 stations listed 555 or 67·8 per cent depend on water for their primary power and only 264 or 32·2 per cent on fuel, the disparity between the two sources of power is much more evident when the other items of the table are considered.

TABLE No. 10—CENTRAL ELECTRIC STATIONS IN CANADA—SUMMARY JANUARY, 1921

—	Canada	Alberta	British Columbia	Manitoba	New Brunswick	Nova Scotia	Ontario	Prince Edward Island	Quebec	Saskatchewan	Yukon
	1	2	3	4	5	6	7	8	9	10	11
Total Number of Stations	819	56	58	28	27	45	360	11	147	83	4
Of hydraulic stations	258	3	30	3	8	14	104	7	88	....	1
Of fuel stations	248	46	20	20	15	24	22	3	14	82	2
Of non-generating	313	7	8	5	4	7	234	1	45	1	1
Total Capital Invested	448,273,642	12,752,477	44,507,332	18,472,471	4,455,293	5,870,668	203,982,142	406,033	149,366,467	86,642	1,374,117
In lands, buildings and fixtures	162,582,537	4,284,740	20,010,659	6,377,757	1,787,059	1,346,992	57,795,814	39,800	69,433,622	7,056,925	649,169
In equipment	148,821,478	4,906,811	9,190,704	3,545,766	1,132,685	2,418,416	81,874,433	222,103	41,639,990	891,956	298,614
In distribution and transmission	80,087,667	3,095,476	12,053,506	7,458,216	930,397	1,843,627	37,380,197	91,395	14,822,194	3,512,087	100,574
In materials, supplies, etc.	9,630,092	175,523	1,113,564	588,966	198,585	101,569	5,039,882	20,677	2,172,703	2,375,848	42,775
In cash trading, accounts, etc.	47,151,868	289,927	2,138,899	501,766	406,569	160,064	21,891,816	32,058	21,297,958	149,826	282,985
Total Revenue from sale of Power	65,705,060	2,653,537	6,743,614	2,715,725	1,107,467	1,903,465	30,303,221	85,889	18,049,908	2,1044,668	97,566
For lighting purposes	25,382,310	1,797,576	2,888,803	1,818,810	764,782	1,396,694	8,928 140	76,011	6,195,936	1,461,140	54,418
For all other purposes	40,322,750	855,961	3,854,811	896,915	342,685	506,771	21,37[illegible] 081	9,878	11,853,972	583,528	43,148
Total Value for Free Service	362,199	14,198	65,352	4,374	12,529	12,714	4[illegible] 534	40	157,216	49,242	....
Total Expenses	45,100,946	1,768,746	3,582,253	2,295,626	800,724	1,531,568	21,17[illegible] 696	73,322	12,226,810	1,587,670	62,531
Salaries and wages	14,626,709	685,596	1,338,882	985,791	238,227	502,692	6,90[illegible] 876	32,911	3,312,605	591,914	33,215
Fuel	3,190,216	534,158	155,421	304,768	330,320	548,806	40[illegible] 838	27,405	124,290	759,091	5,119
Miscellaneous	27,284,021	548,992	2,087,950	1,005,067	232,177	480,070	13,86[illegible] 982	13,006	8,789,915	236,665	24,197
Total Number of Employees	10,693	427	815	654	234	410	5,120	41	2,560	413	19
Total Mileage of Pole line	20,879	924	2,831	1,030	513	798	9,655	61	4,441	558	68
For transmission	7,850	209	965	203	74	157	3,874	21	2,257	34	56
For distribution	13,029	715	1,866	827	439	641	5,781	40	2,184	524	12
Total K.W.H. Generated	5,894,867	114,101	485,177	207,131	25,632	33,731	3,057,124	1,075	1,914,698	47,866	8,332
Primary Equipment— Total Primary Power, H.P.	1,897,024	79,288	213,609	72,050	20,508	24,824	800,501	1,766	632,367	41,891	10,220
Water-wheels and turbines, No.	594	13	54	15	16	15	269	8	202	....	2
Total H.P.	1,754,130	32,380	206,921	68,800	9,063	3,452	797,523	279	625,712	....	10,000

Steam reciprocating eng. No.	196	48	20	16	17	38	18	2	16	20	1
Total H.P.	49,430	12,558	4,633	2,495	5,260	11,583	2,260	500	4,340	5,741	60
Steam turbines No.	37	11	......	......	5	7	......	......	1	12	1
Total H.P.	80,750	32,950	......	......	5,075	9,465	......	......	2,000	31,100	130
Gas and oil engines No.	179	22	13	14	7	5	11	6	9	92	......
Total H.P.	12,714	1,400	2,055	755	1,110	324	718	987	315	5,050	......
Secondary Equipment—											
Total secondary power	1,451,829	60,867	139,819	56,098	14,826	18,134	636,177	1,502	481,609	36,617	6,180
Dynamos A.C., No.	817	65	81	30	39	55	265	13	197	69	3
Total K.V.A.	1,439,937	57,924	138,684	55,766	13,967	16,339	635,004	1,491	479,446	35,166	6,150
Dynamos D.C., No.	165	25	11	13	7	11	2	2	19	55	2
Total K.V.A.	11,892	2,943	1,135	332	859	1,795	1,173	11	2,163	1,451	30

TABLE No. 11.—CENTRAL ELECTRIC TATIONS IN CANADA—COMPARISON OF DATA—WATER VERSUS FUEL POWER STATIONS—JANUARY, 1921

Provinces	Population	No. of Stations			Capital Invested			Revenue from Sale of Power			Total Primary Power			Electrical Energy Generated			
		Total	Hy-dro	Fuel	Total	In hydro stations	In fuel stations	Total	In hydro stations	In fuel stations	Total	In hydro[1] stations	In fuel stations	Total	In hydro stations	In fuel stations	Per capita
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
					$	$	$	$	$	$	H.P.	H.P.	H.P.	Thous	ands of K.	W.H.	
Canada	*8,788,483	819	555	264	448,273,642	419,989,082	28,284,560	65,705,060	56,681,894	9,023,166	1,897,024	1,754,130	142,894	5,894,867	5,730,304	164,563	671
Alberta	588,454	56	5	51	12,752,477	5,347,737	7,404,740	2,653,537	427,664	2,225,873	79,288	32,380	46,908	114,101	61,325	52,776	194
British Columbia	524,582	58	37	21	44,507,332	43,501,302	1,006,030	6,743,614	6,405,208	338,406	213,609	206,921	6,688	485,177	477,344	7,833	925
Manitoba	610,118	28	6	22	18,472,471	17,822,494	649,977	2,715,725	2,417,377	298,348	72,050	68,800	3,250	207,131	204,522	2,609	339
New Brunswick	387,876	27	11	16	4,455,293	1,520,588	2,934,705	1,107,467	208,175	899,292	20,508	9,063	11,445	25,632	9,367	16,265	66
Nova Scotia	523,837	45	16	29	5,870,668	825,388	5,045,280	1,903,465	152,150	1,751,315	24,824	3,452	21,372	33,731	1,741	31,990	64
Ontario	2,933,662	360	338	22	203,982,142	203,618,918	363,224	30,303,221	30,195,853	107,368	800,501	797,523	2,978	3,057,124	3,055,869	1,255	1,042
Prince Edward Island.	88,615	11	8	3	406,033	76,477	329,556	85,889	8,338	77,551	1,766	279	1,487	1,075	46	1,029	12
Quebec	2,361,199	147	132	15	149,366,467	145,936,257	3,430,210	18,049,908	16,778,902	1,271,006	632,367	625,712	6,655	1,914,698	1,911,805	2,893	811
Saskatchewan	757,510	83	......	83	7,086,642	....	7,086,642	2,044,668	....	2,044,668	41,891	....	41,891	47,866	....	47,866	63
Yukon	4,157	4	2	2	1,374,117	1,339,921	34,196	97,566	88,227	9,339	10,220	10,000	220	8,332	8,285	47	2,004

[1]In addition to the water-wheels and turbines listed in column 13 the Hydraulic Station organizations maintain fuel auxiliary or stand-by equipment aggregating 136,592 horse-power or an amount equal to 96·5 per cent of the main fuel station installation.

Under Hydro and Fuel Stations are included details of all non-generating stations buying in bulk from hydro and fuel generating stations respectively.

*Includes 8,473 in N.W.T. and Royal Canadian Navy.

The hydraulic stations represent a capital investment of $419,989,082 or 93·7 per cent as compared with $28,284,560 or 6·3 per cent in fuel stations, earn 86·3 per cent of the total revenue, have a primary power installation of 92·5 per cent of the total main plant installation and generate 97·2 per cent of the total electrical energy reported.

Among the provinces the development of hydro-electric power has made most progress in Ontario largely due to the activities of the Hydro-Electric Power Commission of Ontario, and also to the fact that the province contains no known coal fields. In this province 93·9 per cent of the stations distribute hydro-electric power, the capital involved amounting to 99·9 per cent of the total for the province while the kw. hr. output reaches the surprising total of over 99·95 per cent. It is interesting to note that the per capita consumption is also much larger in this province than in any of the others with the exception of the Yukon where on account of the small population (4,157) and the extensive use of power for mining, the apparent consumption is larger.

According to capital invested in hydro-electric enterprises, primary power installation, revenue and output, Quebec, British Columbia and Manitoba rank next in order although the per capita consumption of power is greater in British Columbia than in Quebec.

Probably the most significant figure which can be quoted in a comparison of this kind is the average revenue received per kw. hr. of output according to source of primary power. When it is stated that the average revenue received by all hydro-electric stations reporting their output amounted to less than 1 cent (0·99 cent) per kw. hr. as against over 5 cents (5·19 cents) per kw. hr., the average revenue of the fuel stations, the advantage to the ultimate consumer of abundant supplies of hydro-electric energy at once becomes apparent.

Dominion Hydrometric Survey

The consolidation in July, 1920, of all stream measurement work of the Department of the Interior and the formation within the Dominion Water Power Branch of a Dominion Hydrometric Survey has during the past year permitted of a fairly complete co-ordination of such work. This central control has not only removed the possibility of duplication but has enabled the institution of more efficient and economic methods of collecting and disseminating hydrometric records. The previous obstacle of limitations on drainage basin investigations through arbitrary interprovincial boundaries has been overcome, and not only are the field investigations now prosecuted in a more logical manner but the publication of the data has been arranged to conform with the major drainage basins of the country. This has ensured an added advantage to the public in that all information relating to one water-shed is now set forth in one publication and furthermore all such publications are available for distribution at one central office.

The various and diversified problems relating to the use and control of water are year by year increasing in number and importance and as a result the demand for fuller knowledge of the regimen of the various lakes and rivers has grown more urgent. To meet these demands the fullest and continued effort of the staff of the survey has been necessary throughout the year.

With the exception of certain of the Pacific coast tributaries no abnormal flood conditions obtained in the past year. On the other hand, run-off was sub-normal in the southern portions of Alberta and Saskatchewan and also in the Maritime Provinces. In the remainder of Canada the run-off was of average amount.

A brief summary of the work of various district organizations is given herewith.

BRITISH COLUMBIA

Hydrometric surveys in the Pacific Coast drainage have been continued under the direction of Mr. R. G. Swan, M.E.I.C., district chief engineer, at Vancouver. The closest co-operation has been maintained throughout with the officers of the Water Rights Branch of the Provincial Government and at their request additional stations, essential to irrigation projects, were established in the interior dry belt. Co-operation was also maintained with the Department of Indian Affairs in the investigation of the water-resources of the Indian Reserves.

Special investigations necessary to a consideration of an international use of boundary rivers were made during the year on the Pend-d'Oreille, Kootenay and Skagit rivers.

Stream measurement records for the Pacific drainage in British Columbia for the climatic year ending September 30, 1921, are being published as Water Resources Paper No. 35.

ALBERTA AND SASKATCHEWAN

In Alberta and Saskatchewan stream measurement work has been carried on under the direction of Mr. A. L. Ford, M.E.I.C., district chief engineer at Calgary. As in the previous year, the closest co-operation has been maintained with the officials of the Reclamation Service.

As a result of deficient precipitation in the southern portions of the two provinces for the fifth consecutive year, there has been a most pressing demand for the fullest investigation of water-resources for irrigation purposes. This has necessitated a material increase in field investigations.

At the current meter rating station at Calgary the regular rating of meters for the survey in Canada and for private individuals was carried out. In addition invaluable ratings were made of special metering equipment.

Other special work included a flood prediction survey in the Bow River valley and an investigation of absorption losses in lake Newell reservoir.

The results of stream measurement investigation in the two provinces for the climatic year ending September 30, 1921, are being published in Water Resources Paper No. 36 covering the Arctic and western Hudson Bay drainage.

MANITOBA

Under the direction of Mr. C. H. Atwood, M.E.I.C., district chief engineer at Winnipeg, the work in Manitoba and Ontario to the west of the Nipigon river has been continued as in the previous year.

At the request of the Manitoba Drainage Commission special investigations were made of the flood run-off of many of the smaller streams in the southern portion of the province.

International problems relating to the use of boundary waters to which attention has been given during the year include the Red, Roseau, and Pigeon rivers.

The stream measurement records for the climatic year ending September 30, 1921 are being published in Water Resources Paper No. 36 covering the Arctic and western Hudson Bay drainage.

ONTARIO

Stream measurement work in Ontario has been continued under the direction of Mr. S. S. Scovil, M.E.I.C., district chief engineer at Ottawa, in close co-operation with the Hydro-Electric Power Commission of Ontario.

In the mining and pulp district north and west of North Bay, the field work has been extended to meet the demands of prospective power development and material assistance and co-operation has been rendered the survey in this district by private corporations actively engaged in the industrial development of the country.

A special office and field investigation of the complex hydrology of the upper Niagara river has been in progress.

The results of stream measurement work in Ontario for the climatic year ending September 30, 1921, are being published in Water Resources Paper No. 34 covering the St. Lawrence and southern Hudson Bay drainage.

MARITIME PROVINCES

In New Brunswick, Nova Scotia and Prince Edward Island, the hydrometric survey has been continued under the direction of Mr. K. H. Smith, M.E.I.C., district chief engineer, at Halifax. In each province the fullest measure of co-operation has been maintained with the provincial authorities.

During the year run-off was greatly deficient and invaluable low-flow records were obtained. Certain special studies were also carried out in connection with storage and stream-flow regulation.

Records of stream measurement work for the climatic year ending September 30, 1921, will be included in a future Water Resources Paper covering the Atlantic drainage south of the St. Lawrence river.

Dominion Water-power and Storage Surveys

The power and storage investigations carried out by the department during the past year in various parts of the Dominion, were chiefly confined to projects of immediate interest. The office analysis of water-power possibilities throughout the Dominion was also actively carried forward both in head office and various field offices.

In British Columbia a study was made of the hydrology of the Columbia river to determine the effects if any on Canadian interests of the proposed Kootenay flats and of the Columbia basin reclamation projects. The analysis of the water-power resources of the province was actively carried on in co-operation with the Provincial Water Rights Branch.

In the Northwest Territories a reconnaissance power survey was made of Alexandra, and Louise falls on the Hay river, about 45 miles from its mouth. These powers are of importance with regard to the development of mineral deposits in the vicinity of Great Slave lake.

In Alberta a reconnaissance power survey was made of the Smith rapids on the Slave river situated near the northern boundary of the province. At Bow falls on the Bow river in Banff additional topographic details were secured in connection with the proposed power development by the Dominion Parks Branch. A reconnaissance survey of the lower Cascade river was made in co-operation with the Calgary Power Company in connection with a proposed power development on that river to augment the capacity of the company's existing plants on the Bow river during periods of low-flow. Attention was given to applications for use of a power site on the Crowsnest river, also to an application for a site on the Belly river. Responsibility for the operation of the lake Minnewanka storage during the filling season was assumed by the department with very satisfactory results during the season of 1921. The systematic analysis of the water-power resources of northern Saskatchewan was continued during the year.

In Manitoba an investigation was made of the possibility of developing power on Birdtail creek at Birtle and installing a hydro-electric system in the

town. Close co-operation was maintained with the Manitoba Power Commission.

In Ontario in the Winnipeg river watershed a reconnaissance survey was made of the power possibilities of the upper English river above Lost lake and also of its tributary, the Sturgeon river. The analysis of the water-power resources of the province was continued in co-operation with the Hydro-Electric Power Commission.

In Quebec the systematic analysis of the water-power resources, developed and undeveloped, was continued based upon the extensive investigatory work carried out by the Quebec Streams Commission and upon other existing sources of reference both federal and provincial.

In New Brunswick a detailed power survey of some seven miles of the Nipisiguit river was commenced in co-operation with the New Brunswick Electric Power Commission. It will be continued during 1922. At the request of municipalities and others who were considering hydro-electric development on a small scale the following small streams were investigated: Upsalquitch river, Caraquet river, Tracadie river, Little Tracadie river, Green river, and Gaspereau river.

In Nova Scotia a detailed power and storage survey of the Bear river was made in co-operation with the Nova Scotia Power Commission. Investigations of the following small streams were also carried out at the request of municipalities and others; Waugh river, Mulgrave brook, Gibraltar Lake stream, Little river, and Maligeak Lake outlets.

In Prince Edward Island at the request of the municipality of Souris an investigation was made of the power possibilities of the Souris river.

Flooded Land Surveys

Dominion land surveys of overflowed lands as they affect the administration of water-power were carried on throughout the year under the direction of Mr. T. H. Dunn, D.L.S., M.E.I.C.

The location of the boundary of the power reserve on Lac du Bonnet was commenced in 1921 at the point on the north shore where the work was left off in 1920, viz., at the east boundary of township 17, range 12, E.P.M., and continued westward to range 11 and south to the north boundary of township 15, where closure was made on the lines of the 1920 survey. This completed the survey of the power reserve around the shore of Lac du Bonnet and of the Winnipeg river within the limits of township 16.

The survey of the power reserve along the Pinawa channel of the Winnipeg river was recommenced at the north boundary of section 29, township 14, range 12, E.P.M., and extended to the northeast corner of section 11, township 14, range 12, E.P.M. This completed the survey of the Pinawa channel except for a very small portion at the extreme upper end. This season's survey on the Pinawa channel was tied into the 1919 survey by locating the east boundary of section 31 in township 14, range 12, E.P.M. The traverse of the power reserve was not continued across section 32, township 14, range 12, as it is not anticipated that any portion of this section will be released for settlement.

In the course of locating the power reserve boundary in sections 3 and 16 of township 16, range 11, E.P.M., it was found that the banks of the lake are very flat and do not rise to elevation 830. At these points it will be necessary to construct a dyke to prevent the overflow of the lake. If allowed to overflow the escaping water would enter Catfish creek and reach lake Winnipeg without re-entering the Winnipeg river. The length of dyke necessary to prevent overflow is 2.4 miles. The same result could be obtained by raising and strengtheneing the present grade of the Winnipeg River railway and would cost less than to

construct a separate dyke. It will be necessary to deepen and improve Catfish creek and construct two branch drains in order to provide drainage for the lands behind the dyke.

During the season 1921 the practice of resurveying all section lines intersected by the traverse was continued as in the years 1919 and 1920.

A topographical survey of that portion of sections N.½ 30, 31, 32 and N.E.¼ 33, township 13, range 12, section 5, township 14, range 12, and S.E.¼ section 36, township 13, range 11, south of the Winnipeg river, was made and contours 900 feet, 903 feet and 905 feet were located for the purpose of determining the most feasible location for a dyke to connect the proposed dam at the Upper Seven Sisters power site with the 905 feet contour on section 32, township 13, range 12. The location of the dyke and contour necessarily fixed the area of each section that would eventually be required in case of development of the power site and indicated the drainage necessary for the lands behind the dyke. It is apparent from the information obtained that the dyke can be most economically constructed along the line between sections 30 and 31 and 29 and 32 for a distance of 1.44 miles. This will constitute the main section of the dyke, but it will be necessary to construct a second section 700 feet long at the west end and a third section 1,000 feet long at the east end in order to connect the main section with the 905 feet contour. The total length of this dyke in addition to the necessary embankment at the dam site in section 36, township 13, range 11, will be 1.75 miles.

During the season 68 miles of section line and 46 miles of chained traverse were run, making a total of 114 miles. This necessitated the construction of monuments on section corners to the number of 108 and the planting of posts on traverse corners to the number of 277. The total number of posts used was 385, of which number 362 were long standard and 23 short standard posts.

Publications

In addition to the annual reports, the branch publishes reports known as Water Resources Papers, and special pamphlets and bulletins. These cover the work and activities of the branch, and make available to the public the results of investigations and hydrometric and water-power data obtained by the various engineers. A list of annual reports and Water Resources Papers published will be found at the end of this report, and copies will be sent on application to those interested, free of charge.

The following reports and bulletins were prepared and published during the year:—

Reports.

1. Annual Report of the branch for the fiscal year ending March 31, 1920.
2. Water Resources Paper No. 28.—Surface water supply of Canada. Report of hydrometric surveys covering the St. Lawrence and southern Hudson Bay drainage in Ontario for the climatic year ending September 30, 1920, by S. S. Scovil, district chief engineer.
3. Water Resources Paper No. 29.—Surface water supply of Canada. Report of hydrometric surveys covering the Atlantic drainage south of the St. Lawrence river including Nova Scotia, New Brunswick and Prince Edward Island and southwestern Quebec, for the climatic years ending September 30, 1920, and September 30, 1921, by K. H. Smith, district chief engineer.
4. Water Resources Paper No. 30.—Surface water supply of Canada. Report of hydrometric surveys covering the Pacific drainage in British Columbia and the Yukon Teritory, for the climatic year ending September 30, 1920, by R. G. Swan, district chief engineer.

Bulletins.

1. Hydro-Electric Progress in Canada, February 1, 1922.
2. Water-power in the Pulp and Paper Industry in Canada, February 2, 1922.
3. Water-power Resources of Canada, March 1, 1922.

Reports now in Press.

1. Annual Report of the branch for the fiscal year ending March 31, 1921.
2. Water Resources Paper No. 32.—Water Resources Index Inventory by J. T. Johnston. Description of the Index Inventory System for recording and collating the water resources data of the Dominion.

Reports in Course of Preparation.

1. Water Resources Paper No. 31.—Surface water supply of Canada. Report of hydrometric surveys covering the Arctic and western Hudson Bay drainage (and Mississippi drainage in Canada) in Alberta, Saskatchewan, Manitoba, extreme western Ontario and the Northwest Territories, for the climatic year ending September 30, 1920, by C. H. Attwood, district chief engineer, Winnipeg, and A. L. Ford, district chief engineer, Calgary.
2. Water Resources Paper No. 33.—Directory of Central Electric Stations in Canada to November 1, 1922. Comprises an analysis of the central electric station statistics and a directory of the stations.
3. Water Resources Paper No. 34.—Surface water supply in Canada. Report of hydrometric surveys covering the St. Lawrence and southern Hudson Bay drainage in Ontario for the climatic year ending September 30, 1921, by S. S. Scovil, district chief engineer.
4. Water Resources Paper No. 35.—Surface water supply of Canada. Report of hydrometric surveys covering the Pacific drainage in British Columbia and the Yukon Territory for the climatic year ending September 30, 1921, by R. G. Swan, district chief engineer.

PART 2

FIELD REPORTS

PART II

FIELD REPORTS

DISTRICT OF BRITISH COLUMBIA

During the fiscal year ending March 31, 1922, regular stream measurement investigatory operations of the Dominion Water-Power Branch in the province of British Columbia were continued in accordance with the terms of the co-operative agreement of August, 1913, between the Department of the Interior at Ottawa and the Provincial Government.

ORGANIZATION

The work in British Columbia is directed from the district office at Vancouver with a branch office at Kamloops. For purpose of administration and convenience of field operations, the arrangement of the territory into districts is practically the same as instituted in 1914. While the primary object of this district organization is the acquiring and tabulating of stream-flow data for purposes of power development, irrigation, domestic water supply, etc., the services of the engineers of this staff are frequently utilized by other Dominion Government departments, in connection with investigations, which require hydraulic engineering knowledge. This particularly applies to the investigation of Indian Water Rights made on behalf of the Department of Indian Affairs, which necessitated the maintenance of an engineering party in the field continuously throughout the season as well as an engineer to look after the Indian interests before the Board of Adjudication under Water Act.

CO-OPERATION

As already stated, all hydrometric studies in British Columbia are made under the co-operative agreement with the Provincial Government and every effort is made to meet the requests of the Comptroller of Water Rights for stream-flow data. Stations are maintained on the Columbia, Pend-d'Oreille and Skagit rivers, very important international streams, in co-operation with the Water Resources Branch of the United States Geological Survey.

The compilation of information, which was collected by Messrs. Balls and Phillips on the status of water rights appurtenant to Indian Reserves was completed. Reports on water records in the Kamloops Indian Agency and Okanagan Indian Agency were prepared by Mr. Balls. Report on water records in the Kootenay Indian Agency was prepared by Mr. Phillips. These reports were presented to the Board of Adjudication under Water Act at hearings held by the board at Merritt, Kamloops, Penticton and Keremeos, on July 15-22 and at Cranbrook on August 26. Further investigations for the Indian Department were carried on by Mr. Phillips.

HYDROMETRIC SURVEY

Owing to rains throughout the whole summer, the streams of both the Kamloops and coast districts held up well above the average; whilst, temperatures being moderate no extremely high-water was experienced in the interior.

In October and December two serious floods occurred along the coast. The flood of October was particularly acute in the vicinity of Vancouver. At Britannia Mines some thirty-five persons lost their lives in the swollen Britannia creek, which flooded the town. Although not so great, the flood of December did considerable damage and was particularly felt in the Chilliwack district, where the river destroyed protection work along its course and flooded the country for miles around.

The several new stations, which were established along the coast last year have been maintained and during this coming year it is the intention of the branch to extend the investigations further up the coast in co-operation with the Provincial Water Rights Branch. At the request of the Liberator Mining Company, which contemplates the installation of a small hydro-electric plant to operate their mill and compressors, new stations were established on Coquihalla river at Emancipation siding and on Dewdney creek in the same locality.

The Okanagan district, which had previously been worked from the Kamloops office, is now being directed from the head office in Vancouver. This change was considered advisable for the better organization of the work. Seventeen new gauging stations were established in this district in connection with investigations for the Vernon and Okanagan Falls irrigation district.

In the Kamloops district an average of eighty-three gauging stations were maintained throughout the irrigation season. There were nine stations established during the year at the request of the Provincial Water Rights Branch. It has been found that weirs, which have been in use for some time in the Kamloops division are not altogether satisfactory, the velocity of approach at high-water being a feature, which is most difficult to overcome. For this reason, it is not proposed to install any more Cippoletti weirs, but to establish rating flumes wherever possible.

In the Kootenay district the work was carried on in practically the same manner as that of the previous year. There were many new stations established, both in the east and west Kootenay, particularly in irrigation streams at the request of the provincial authorities. Ice measurements have been made in this district throughout the winter months. Special investigations of the low-flow of the Skookumchuck river were made during the winter months for the Canadian Consolidated Mining and Smelting Company.

Below are a list of the regular and miscellaneous metering stations maintained during the past year:—

REGULAR GAUGING STATIONS

PACIFIC COAST DRAINAGE

Index Number	Stream	Location
$8HB_5$	Nanaimo	At Canadian Collieries bridge.
$8HB_4$	Little Qualicum	At Outlet from Cameron lake.
$8HB_1$	Big Qualicum	Near mouth.
$8HB_{10}$	Stamp	At Stamp falls.
$8HB_8$	Sproat	At Sproat lake.
$8HD_1$	Campbell	At Campbell lake.
$8GA_{20}$	Rainy	At Port Melon.
$8GA_{17}$	Cheakamus	Watson.
$8GA_{16}$	Brandywine	Near mouth.
$8GA_{10}$	Capilano	Above City intake.
$8GA_{13}$	Seymour	Above City intake.
$8GA_5$	Mesliloet	Upper station.
$8GA_8$	Brandt	Above Young creek.
$8GA_6$	Norton	Norton lake.
$8GA_{15}$	Flume	Near mouth, 5 miles from Wigwam.
$8GA_1$	Belknap	Belknap lake.

REGULAR GAUGING STATIONS—*Continued*

FRASER RIVER DRAINAGE BASIN

Index Number	Stream	Location
$8MF_5$	Fraser	At Hope.
$8MD_2$	Pavilion	Three miles above mouth.
$8MA_1$	Fountain	Six miles above mouth.
$8ME_1$	Bridge	At highway bridge; 10 miles from Mission.
$8ME_2$	Cayoosh	At railway bridge, one-half mile from mouth.
$8MF_{14}$	Riley	Two miles above mouth.
$8MF_{15}$	Texas	One mile above mouth.
$8MF_{20}$	Cinquefoil	Above diversions, 3 miles from mouth.
$8MF_{23}$	Cinquefoil ditch	Lochore creek.
$8MF_{22}$	Lochore	Above diversion, one mile from mouth.
$8MF_{16}$	Foster Bar	Two miles above mouth.
$8MF_{21}$	Izman	One mile above mouth.
....	Thompson river	"*See* Thompson River Tributary Basin".
$8MF_7$	Nahatlatch	Below Nahatlatch lake.
$8MF_8$	Nahatlatch	Seven miles from mouth.
$8MF_3$	Coquihalla	At highway bridge near mouth.
$8MF_{12}$	Nicolum	At ninemile bridge.
$8MF_6$	Jones	At outlet of Jones lake.
$8MF_2$	Boulder	Near mouth.
$8MH_1$	Chilliwack	At Vedder crossing.
$8MG_3$	Green	At Nairn falls.
$8MH_{14}$	Alouette	Near Alouette lake.

NORTH THOMPSON RIVER TRIBUTARY BASIN

$8LB_{22}$	North Thompson	Above Barriere.
$8LA_1$	Clearwater	One mile above mouth.
$8LB_{33}$	Dunn	One and a half miles above Dunn lake.
$8LB_{31}$	Nelson	Above diversions, two miles from mouth.
$8LB_{32}$	Peterson	Near Barriere, one mile above mouth.
$8LB_{20}$	Barriere	One mile above mouth.
$8LB_{30}$	Gordon	Above Genier's upper diversion.
$8LB_{28}$	Sullivan	At Canough lake two hundred yards below dam.
$8LB_5$	Heffley	Two miles below Heffley lake.
$8LB_4$	Heffley	Above diversion, near mouth.
$8LB_3$	Edwards	Three miles from mouth.
$8LB_{23}$	Edwards	Lyon's diversions.
$8LB_{13}$	Paul	Below Paul lake.
$8LB_{27}$	Paul	Above diversions, near mouth.

SOUTH THOMPSON RIVER TRIBUTARY BASIN

$8LE_{31}$	South Thompson	At Chase.
$8LC_3$	Shuswap	At Shuswap falls.
$8LC_2$	Shuswap	At Enderby.
$8LC_{14}$	Jones	Below Haddo lake.
$8LC_{17}$	Dermont	At outlet of Aberdeen Lake.
$8LC_6$	Jones	Below White Valley diversion.
$8LC_7$	Jones	White Valley diversion.
$8LC_{10}$	Nickelin	Below Hallam lake.
$8LC_{15}$	Paradise	Near headwaters.
$8LE_{27}$	Seymour	Three miles above mouth.
$8LE_{19}$	Salmon	Above Grand Prairie.
$8LE_{20}$	Salmon	Below Bolean creek.
$8LE_6$	Pringle	Below Monte lake.
$8LE_8$	Ingram	Above diversions, near mouth.
$8LE_1$	Bolean	One mile above mouth.
$8LE_{38}$	Blair	Above diversions, three-quarters mile from mouth.
$8LE_{39}$	White	At outlet of Little White lake.
$8LD_1$	Adams	Below Adams lake.
$8LD_2$	Bear	Six miles above mouth.
$8LE_5$	Chase	Four miles above mouth.
$8LE_{32}$	Niskonlith	Above Niskonlith lake.
$8LE_{33}$	Loakin	Above Indian diversion.
$8LE_{10}$	Martin	Above diversions, near mouth.
$8LE_{34}$	Neds	Above upper diversion.
$8LE_{15}$	Neds	Above diversion, near mouth.
$8LE_{12}$	Monte	Below diversion to Monte lake.
$8LE_{11}$	Monte	Diversion to Monte lake.
$8LE_{13}$	Monte	Above Bostock diversion.
$8LE_{22}$	Robbins	Above Buce meadows.
$8LE_{37}$	Campbell	Above Scuittoe creek.
$8LE_{36}$	Scuittoe	Above diversions, near mouth.
$8LE_{35}$	Peterson	Below Jacko lake.

REGULAR GAUGING STATIONS—*Continued*

THOMPSON RIVER TRIBUTARY BASIN

Index Number	Stream	Location
$8LF_{22}$	Thompson	At Spences bridge.
$8LF_{24}$	Tranquille	Below small diversion, one mile from mouth.
$8LF_{5}$	Cherry	Above Alkali creek.
$8LF_{32}$	Threemile	Below Ferguson's diversion.
$8LF_{30}$	Threemile	Ferguson's diversion.
$8LF_{27}$	Deadman	Above Crise creek.
$8LF_{7}$	Criss	One-half mile above mouth.
$8LF_{1}$	Barnes	Above Barnes lake.
$8LF_{2}$	Bonaparte	Five miles above mouth.
$8LF_{21}$	Scottie	Above diversions, near mouth.
$8LF_{13}$	Hat	Above Hammond diversion to Oregon Jack creek.
$8LF_{14}$	Hat	Hammond's diversion to Oregon Jack creek.
$8LF_{34}$	Hat	Above Marble canyon.
$8LF_{6}$	Cornwall	Above diversions, near mouth.
$8LF_{19}$	Oregon Jack	Above Hammond's diversion.
$8LF_{36}$	Pu-Kaist	Six miles above mouth.
$8LG_{13}$	Nicola	At Nicola.
$8LG_{18}$	Spohomin	Seven miles above mouth.
$8LG_{16}$	Penask	One-half mile above Penask lake.
$8LG_{11}$	Beaver	Five miles above Nicola lake.
$8LG_{15}$	Clapperton	Two miles above mouth.
$8LG_{10}$	Coldwater	Three miles above Merritt.
$8LG_{3}$	Guichon	Above Mamette lake.
$8LG_{14}$	Guichon	Leighton's diversion to Threemile creek.
$8LG_{9}$	Witches	One mile above mouth.
$8LG_{1}$	Chartrand	One mile above mouth.
$8LG_{5}$	Meadow	One mile above mouth.
$8LG_{19}$	Willow	One mile above mouth.

SKAGIT RIVER DRAINAGE BASIN

$8NL_{1}$	Skagit	Near boundary.
$8NL_{3}$	Sumallo	Eight miles from mouth.
$8NL_{2}$	Sumallo	One mile from mouth.

COLUMBIA RIVER DRAINAGE BASIN

$8NA_{2}$	Columbia	At Golden.
$8ND_{2}$	Columbia	At Revelstoke.
$8NE_{3}$	Columbia	Near trail.
$8NA_{24}$	Windermere	Near Windermere.
$8NA_{1}$	Bugaboo	Near Spillimacheen.
$8NA_{11}$	Spillimacheen	Near Spillimacheen.
$8NA_{6}$	Kicking Horse	At Golden.
$8ND_{1}$	Akolkolox	Near Wigwam.
$8NE_{11}$	Sevenmile	Near Brouse.
$8NE_{9}$	Incomappleux	Near Edgewood.
$8NE_{13}$	Irrigation	Near mouth.
....	Kootenay	*See* Kootenay river tributary basin.
$8NE_{10}$	Pend-d'Oreille	Near Metaline falls, Wash.

REGULAR GAUGING STATIONS—*Continued*

KOOTENAY RIVER TRIBUTARY BASIN

Index Number	Stream	Location
$8NG_5$	Kootenay	At Wardner.
$8NJ_9$	Kootenay	At Nelson.
$8NJ_1$	Kootenay	At Glade.
$8NG_3$	Cherry	Near Wasa.
$8NG_{14}$	Joseph	Heath's ranch, near Cranbrook.
$8NG_{15}$	Joseph	Cranbrook.
$8NG_2$	Bull	Near mouth.
$8NG_{11}$	Little Sand	Near Jaffray.
$8NG_{10}$	Big Sand	Near Jaffray.
$8NK_1$	Elk	Near Elko.
$8NG_8$	Phillips	Near Roosville.
$8NG_6$	Linklater	Near Newgate.
$8NH_{11}$	Huscroft	Above flume diversion.
$8NH_{13}$	Rykerts	Above dam and intake.
$8NH_4$	Goat	Near Erickson.
$8NH_{14}$	Sullivan	At intake.
$8NH_9$	Camp Run	Above proposed diversion.
$8NH_8$	Burton	Above mill intake.
$8NH_{12}$	Lizard	At Jackson's ranch.
$8NH_{16}$	Duck	Above Offner's ranch.
$8NH_{10}$	Huggard	Near mouth.
$8NH_{15}$	Wiles	Above diversions.
$8NJ_{21}$	Proctor	Above diversions.
$8NJ_{20}$	Narrows	Above diversions.
$8NJ_{19}$	Laird	Above diversions.
$8NJ_{22}$	Greenwood	Above diversions.
$8NJ_{24}$	Slater	Above diversions.
$8NJ_{23}$	Sandy	Above diversions.
$8NJ_{18}$	Falls	Above diversions.
$8NJ_{14}$	Slocan	Slocan City.
$8NJ_{16}$	Jerome	Above diversions.
$8NJ_{15}$	Richards	Above diversions.
$8NJ_{25}$	Cants	Above diversion.
$8NJ_{17}$	Percy	Above diversion.

KETTLE RIVER TRIBUTARY BASIN

$8NN_3$	Kettle	West Fork at Wescbridge.
$8NN_4$	Kettle	At Kettle valley.
$8NN_5$	Kettle	At Carson.
$8NN_6$	Kettle	At Cascade.
$8NN_7$	Rock	Above Irrigation Company's intake.
$8NN_8$	Pass	Above diversion.
$8NN_9$	McConnell	Above Padgett's intake.

OKANAGAN RIVER TRIBUTARY BASIN

$8NM_2$	Okanagan	At Okanagan falls.
$8NM_{21}$	Long lake	At Vernon.
$8NM_{20}$	B. X. creek	Above Goose lake diversion.
$8NM_{22}$	Woods	Below Beaver lake.
$8NM_{43}$	Woods	Below Okanagan centre diversion.
$8NM_9$	Duck	Below diversions.
$8NM_{48}$	Oyama	Above Oyama diversion.
$8NM_{28}$	Oyama	Oyama diversion.
$8NM_{24}$	Sixmile	Above Indian Reserve.
$8NM_{47}$	Siwash	Three miles above mouth.
$8NM_{46}$	Whiteman	Above lower diversions, near mouth.
$8NM_{26}$	Mill	Above diversions.
$8NM_{16}$	Mission	Above Hydraulic creek.
$8NM_{10}$	Hydraulic	Below S. K. L. diversion.
$8NM_{39}$	Hydraulic	S. K. L. diversion above Canyon creek.
$8NM_{40}$	Hydraulic	S. K. L. diversion below Canyon creek.
$8NM_4$	Canyon	Above S. K. L. syphon.
$8NM_{35}$	Sawmill	Above diversion.
$8NM_3$	Bear	Below diversions, near mouth.
$8NM_{14}$	McDougall	Above diversions.

REGULAR GAUGING STATIONS—*Concluded.*

OKANAGAN RIVER TRIBUTARY BASIN—*Concluded*

Index Number	Stream	Location
SNM_{33}	Powers	Above westbank diversions.
SNM_{34}	Powers	Westbank diversion.
SNM_{41}	Trepanier	Above Jack creek.
SNM_{29}	Peachland	Below Peachland diversion.
SNM_{30}	Peachland	Municipal irrigation diversion.
SNM_{42}	Trout	Below all diversions.
SNM_{25}	Darke	At Meadow valley.
SNM_{23}	Darke	Northwest fork.
SNM_{7}	Chute	One mile below Chute lake.
SNM_{31}	Penticton	Below Penticton diversion.
SNM_{32}	Penticton	Municipal irrigation diversion.
SNM_{37}	Sheep	Above Kaleden diversion.
SNM_{38}	Shingle	Above diversions.
SNM_{5}	McLean	Above diversions.
SNM_{6}	Shuttleworth	Above Shuttleworth diversion.
SNM_{15}	McIntyre	Above diversions, near mouth.
SNM_{12}	Incaneep	Three miles from mouth.

SIMILKAMEEN RIVER TRIBUTARY BASIN

SNL_{6}	Similkameen	Below Ashnola creek.
SNL_{12}	Allison	Below Summers creek.
SNL_{13}	Summers	Near mouth.
SNL_{14}	Keremeos	Six miles above Olalla.
SNL_{10}	Keremeos	Below Olalla creek.
SNL_{11}	Olalla	Near mouth.

MISCELLANEOUS GAUGING STATIONS

PACIFIC COAST DRAINAGE BASIN

SHA_{2}	Cowichan	At outlet from lake.
SHB_{6}	Puntledge	One mile from mouth.
	Somenos	At highway bridge.
SHB_{9}	Stamp	At Great Central lake.
SGB_{2}	Clowhom	At outlet of Lower lake.
SGB_{3}	Eagle	At outlet of First Gordon Pasha lake.
SGA_{12}	Lynn	Below waterworks intake.
SGA_{9}	Belknap	Below Ann lake.
SGA_{11}	Hixon	Above Belknap creek.
SGA_{7}	Young	At mouth.

FRASER RIVER DRAINAGE BASIN

	Cayoosh	Copeland ditch.
	Copeland springs	Above Paynter's ranch.
SMF_{19}	Island bar	Above ditches.
SMF_{13}	Laluwissin	Above irrigation ditches.
	Na Kai	Below Lytton.

NORTH THOMPSON RIVER TRIBUTARY BASIN

SLA_{3}	Murtle	15 Miles above mouth.
	North Thompson (B.C. Fruitlands flume)	Below pumping station.
	Peterson (Eggleston flume)	Above Barriere.
	Peterson (Dominion Experimental Farm flume).	Above Barriere.

MISCELLANEOUS GAUGING STATIONS—*Concluded*

SOUTH THOMPSON RIVER TRIBUTARY BASIN

Index Number	Stream	Location
$8LC_{16}$	Aberdeen	At outlet of Aberdeen lake.
$8LC_{11}$	Gold—East fork	Near headwaters.
$8LC_{12}$	Gold—Centre fork	Near headwaters.
$8LC_{13}$	Gold—West fork	Near headwaters.
$8LE_{25}$	Celista	Near mouth.

THOMPSON RIVER TRIBUTARY BASIN

$8LF_{35}$	Hat	Near mouth.
	Cache	Above Semlin ranch.
$8LF_{29}$	Cache (McAbes diversion)	

COLUMBIA RIVER DRAINAGE BASIN

$8NA_{14}$	Dutch	Near Fairmont springs.
$8NA_{26}$	Goldie	Near Invermere.
$8NA_{16}$	Shuswap	Near Athalmer.
$8NA_{20}$	Stoddart	Near Athalmer.
$8NA_{28}$	Boulder (main ditch)	Near Wilmer.
$8NA_{29}$	Boulder	Near Wilmer.
$8NA_{9}$	No. 2	Near Wilmer.
$8NA_{18}$	Sinclair	Near Sinclair.
$8NA_{22}$	Little Vermilion	Near Edgewater.
$8NA_{21}$	Big Vermilion	Near Edgewater.
$8NA_{8}$	Kicking Horse	No. 2 tunnel.
$8NA_{7}$	Kicking Horse	Near Field.
$8NE_{12}$	Incomappleux	Near Camborne.
$8NE_{14}$	Pass	5 miles above mouth.
$8NE_{15}$	Erie	Near mouth.

KOOTENAY RIVER TRIBUTARY BASIN

	Skookumchuck	At Skookumchuck.
$8NG_{16}$	Sheep	Near Wasa.
$8NG_{12}$	St. Mary	Near Wycliffe.
$8NG_{20}$	Mathew	Near Marysville.
$8NG_{19}$	Mark	Near Kimberley.
$8NG_{7}$	Mark	Near Marysville.
$8NG_{9}$	Rock	Near Elko.
$8NG_{17}$	Gold	12 miles from Cranbrook.
$8NH_{17}$	Arrow	Near mouth.
$8NM_{26}$	Mill	Above diversions.
$8NJ_{26}$	Duhamel	Above Whitehouses diversions.
$8NJ_{13}$	Slocan	Near Crescent valley.

OKANAGAN RIVER TRIBUTARY BASIN

$8NM_{50}$	Okanagan	Above Dog lake.
$8NM_{19}$	Mission	Belgo diversion.
	Trout	Above Faulder diversion.

SIMILKAMEEN RIVER TRIBUTARY BASIN

$8NL_{5}$	Tulameen	Railway bridge, 2 miles above mouth.
$8NL_{18}$	Fivemile	Ten miles below Chain lake.

GAUGING STATIONS WITHOUT DISCHARGE RECORDS

$8LF_{23}$	Thompson	At Kamloops.
$8LG_{30}$	Penask	South west corner of lake.

POWER SURVEY

The preparation and compilation of the water-power resources inventory of the province has been continued in co-operation with the Provincial Water Rights Branch and in accordance with the standard principles of the water resources inventory. During the year write-ups of undeveloped power and undeveloped reservoir sites were completed and many power river write-ups were prepared, thus adding much valuable data to this inventory.

A study of the hydrology of the Columbia river was made to determine the effects, if any, on Canadian interests of the proposed Kootenay flats reclamation project, and of the Columbia basin reclamation project.

HYDRO-ELECTRIC CONSTRUCTION

Construction on hydro-electric power plants in British Columbia has been more active during the year than for some time past.

The Nanaimo Electric Light, Power and Heat Company, Limited, of Nanaimo, B.C., completed a 200-horse-power installation on Coal creek.

British Columbia and Alberta Power Company, Limited, of Fernie, B.C., have practically completed the installation of their 6,000 horse-power plant on the Bull river and are now preparing plans for development of 10,000 horse-power on the Elk river at Elko.

The British Columbia Electric Railway Company, Limited, which now owns the Western Power Company, have started work on the installation of the fourth unit of 13,500 horse-power at the Stave Lake power plant. This necessitates the enlarging of present dam at Stave lake. It is proposed to raise the crest of dam to an elevation of 235 feet, which is 17 feet above its present height.

GENERAL COMMENTS

A keen interest in all engineering problems presented to them by other Government Departments has been taken by the engineers of the Water-Power Branch in the province and they have always endeavoured to render every assistance possible. In the interior the scope for this assistance is increasing rapidly.

The chief engineer attended an important conference of the Columbia River Board at Seattle on February 14. This meeting was attended by board members and engineers of the different departments of the United States Government, which are interested in the development of the Columbia river. The conference, so far as the district chief engineer was concerned, was entirely informal and no action was taken by the board.

The chief engineer and assistant chief attended an informal conference held at the Parliament Buildings, Victoria on March 24, at which discussion was held with a view to controlling the flow of the Coquitlam river, so that in the future, damage and loss of property from floods may be averted. Representative engineers from provincial and federal departments as well as other interested parties attended this conference, the outcome of which has resulted in action being taken to prepare plans to cope with the situation.

RECOMMENDATIONS

Very little enlargement of the scope of the work has been possible due to the necessary practice of greatest economy. There are still a large number of streams in the province upon which no hydrometric data has yet been obtained and upon which, before many years, as the development of the country expands,

data will be of great importance. Special reference is made to the northern coast and northern interior. When funds are available it is essential that work should be extended into these districts.

PUBLICATIONS

The most recent publication of the work in British Columbia is Water Resources Paper No. 30. This paper covers the hydrometric investigations for the climatic year ending September 30, 1920. Report No. 35, covering the work for the year ending September 30, 1921 has been prepared and forwarded to Ottawa for publication.

R. G. SWAN,
District Chief Engineer.

DISTRICT OF ALBERTA AND SASKATCHEWAN

During the fiscal year ending March 31, 1922, the regular stream measurement and power investigatory operations of the Dominion Water Power Branch in the provinces of Alberta and Saskatchewan were continued.

The scope of the work covered by this district organization comprises the hydrometric survey and the power and storage investigatory work in the two provinces, including the Peace River block in British Columbia, but excluding the Churchill river area in northern Saskatchewan.

ORGANIZATION

Stream measurement work started in these provinces in 1894 and was continued on a small scale by the Canadian Irrigation Surveys until 1909. From 1909 to 1911 the hydrometric survey was under the Forestry and Irrigation Branch of the department and from 1911 to 1920 under the Irrigation Branch. On July 1, 1920, it was transferred to the Dominion Water Power Branch and has since continued under that branch.

The stream measurement operations are now controlled from the district office at 513, 8th Avenue west, Calgary, and embrace practically the whole of the provinces of Alberta and Saskatchwan. The large extent of this area necessitates engineers being placed in charge of various sub-districts and the work, therefore, requires continual supervision from the district office. For this reason the whole of the stream measurement work is divided into two divisions, namely, northern and southern, each of which is in charge of a division hydrometric engineer with headquarters at Calgary.

CO-OPERATION

The closest co-operation is maintained with the Reclamation Service which depends on our hydrometric survey for its stream-flow data. Hydrometric data is just as available to reclamation officers as it was previous to the transfer of the hydrometric survey. In addition special studies of absorption losses, etc., etc., have been made by this branch whenever requested by the Director of Reclamation.

All hydrometric work in connection with the international problem of the division of the waters of the St. Mary and Milk rivers has been carried on under the direction of the Director of Reclamation, Canada's accredited officer in this connection. The fullest co-operation has been continued with the Montana division of the United States Geological Survey and the United States Reclamation Service in the measurement of international waters on the Montana-Alberta and Saskatchewan portion of the boundary.

At all points on the irrigation projects operated by the Canadian Pacific Railway, Department of Natural Resources, where measurement of diverted water is necessary, our engineers have co-operated with those of the company. Jointly with the Reclamation Service and the hydrometric staff of the Department of Natural Resources, Canadian Pacific Railway, this office held a two-day conference on hydrometric methods and procedure, resulting in much benefit to members of all three staffs.

With the co-operation of the Calgary Power Company's staff at Seebe Alberta, the work of rating the plant was continued under the direction of Mr. G. H. Whyte, assistant district chief engineer. Mr. Planche of our Calgary staff and Mr. Rose of the Winnipeg staff co-operated with Mr. G. A. Gaherty, Calgary Power Company engineer, in the preliminary survey of the proposed Cascade River power scheme.

At the request of the Director of the Meteorological Service, inspections of meteorological stations throughout the two provinces were made during the course of the year. Reports on the condition of these stations were sent to the head office of the Meteorological Service at Toronto. Mr. N. B. Sanson, meteorological observer at Banff, accompanied the district chief engineer and the assistant district chief engineer, on the annual flood-warning survey at the head waters of the Bow river.

In co-operation with the universities of Alberta and Saskatchewan field demonstrations were given for the students. In addition, lectures on the subjects of hydrometric and water-power engineering were given at each university.

THE HYDROMETRIC SURVEY

The extensive demand for information as to stream-flow which was noted in 1920 was again marked during the past year. The rainfall of 1921 was even less than in 1920 throughout the southern portions of Alberta and Saskatchewan, and the resulting interest in irrigation was greater than ever before. Records required for use in connection with drainage projects while again in demand did not show the increase which was noted in 1920.

The spring of 1921 was rather earlier than usual but following a mild winter with little snowfall there was less than the usual run-off and high stages were not recorded on any of the southern streams although heavy snowfalls in northern Saskatchewan during March resulted in very high stages on all streams in that area during the breakup period. The precipitation during the summer of 1921 for the fifth successive growing season was below average. The ground water-level receded further and several sloughs and lakes went dry for the first time in many years. This dry summer was followed by a winter of more than usual severity and the new minimum stages were recorded on almost all streams. Several streams which have never been known before to cease flowing were so recorded during the winter. Generally speaking, the run-off for the year was well below the average for a ten-year period.

While it was considered that several stations might be discontinued due to the completion of a ten-year period of record it was decided to continue them until the annual run-off definitely increased so that full records covering the minimum portion of a cycle might be obtained. The increased demands for records in connection with irrigation and drainage necessitated the establishment of a number of new stations and the re-opening of a number which had previously been abandoned. This resulted in the total number of stations at the end of the year being larger than at the end of the previous year.

The ruling of the International Joint Commission of October 4, 1921, in regard to the waters of the Milk and St. Mary rivers will necessitate the establishment during the coming year of a number of new stations on diversions from the tributaries of the Milk river in Saskatchewan. To obtain the desired

information so that the ruling of the International Joint Commission can be properly applied will also necessitate certain investigations as to carriage losses in the streams affected. In this work this branch will co-operate with the Reclamation Service.

Below are listed the regular and miscellaneous gauging stations which were maintained during the year.

REGULAR GAUGING STATIONS

Nelson River Drainage Basin

ASSINIBOINE RIVER TRIBUTARY BASIN

Index Number	Stream	Location
$5NB_4$	Beaverdam creek	Near Weyburn.
$5NB_1$	Long creek	Near Estevan.
$5JE_1$	Moose Jaw creek	At McCarthy's farm.
$5JF_1$	Qu'Appelle river	At Lumsden.
$5NB_2$	Souris river	Near Estevan.

SASKATCHEWAN RIVER TRIBUTARY BASIN

Index Number	Stream	Location
$5KA_3$	Carrot river	At Baulieu's farm.
$5KA_1$	Carrot river	Near Kinistino.
$5KA_4$	Dead river	Near Kinistino.

NORTH SASKATCHEWAN RIVER TRIBUTARY BASIN

Index Number	Stream	Location
$5FF_2$	Battle river	Near Battleford.
$5FA_1$	Battle river	At Ponoka.
$5EB_2$	Beaverhill creek	Near Mundare.
$5DB_1$	Clearwater river	Near Rocky Mountain House.
$5EB_6$	Cooking Lake creek	Near North Cooking lake.
$5EB_1$	Hastings creek	Near Lindbrook.
$5EG_2$	Jackfish creek	Near Meota.
$5DF_1$	North Saskatchewan river	At Edmonton.
$5EF_1$	North Saskatchewan river	Near Fort Pitt.
$5GG_1$	North Saskatchewan river	At Prince Albert.
$5DC_1$	North Saskatchewan river	Near Rocky Mountain House.
$5DE_1$	North Saskatchewan river	Near Rocky rapids.
$5DC_2$	North Saskatchewan river	Near Saunders.
$5EA_1$	Sturgeon river	Near Fort Saskatchewan.
$5EA_2$	Sturgeon river	At St. Albert.

SOUTH SASKATCHEWAN RIVER TRIBUTARY BASIN

Index Number	Stream	Location
$5AJ_1$	South Saskatchewan river	At Medicine Hat.
$5HG_1$	South Saskatchewan river	At Saskatoon.

OLDMAN RIVER TRIBUTARY BASIN

Index Number	Stream	Location
$5AB_{13}$	Beaver creek	Near Brockett.
$5AA_3$	Castle river	Near Cowley.
$5AA_2$	Crowsnest river	Near Lundbreck.
$5AA_{14}$	Elton ditch	Near Cowley.
$5AB_{14}$	Fivemile creek	Near Spring Point.
$5AA_{17}$	Huff ditch	Near Cowley.
$5AB_6$	Muddypound creek	At Hart's ranch.
$5AB_{12}$	Oldman river	At canal intake.
$5AA_1$	Oldman river	Near Cowley.
$5AD_7$	Oldman river	Near Lethbridge.
$5AB_7$	Oldman river	Near Macleod.
$5AA_4$	Pincher creek	At Pincher creek.
$5AB_3$	Trant creek	At Lockwood ranch.
$5AB_2$	Willow creek	Near Macleod.

REGULAR GAUGING STATIONS—*Continued*

BELLY RIVER TRIBUTARY BASIN

Index Number	Stream	Location
$5AD_5$	Belly river	Near Mountain View.
$5AD_2$	Belly river	At Stand Off.
$5AD_9$	Christianson ditch	Near Caldwell.
$5AD_1$	Mami creek	At Mountain View.

WATERTON RIVER TRIBUTARY BASIN

Index Number	Stream	Location
$5AD_4$	Crooked creek	Near Waterton Park.
$5AD_{10}$	Drywood river	Near Fishburn.
$5AD_8$	Waterton river	Near Stand Off.
$5AD_3$	Waterton river	Near Waterton Park.

ST. MARY RIVER TRIBUTARY BASIN

Index Number	Stream	Location
$5AE_4$	A. R. and I. Co.'s canal	At Kimball.
$5AE_{15}$	A. R. and I. Co.'s canal	Near Magrath.
$5AE_{14}$	A. R. and Lateral canal	Near Magrath.
$5AE_{10}$	A. R. and I. Co.'s canal	At Spring Coulee.
$5AE_{0.4}$	Canyon creek	Near Many Glaciers.
$5AE_{13}$	Hillmer Bros. ditch	Near Boundary creek.
$5AE_{19}$	Jensen and Powell lower	Ditch near Taylorville.
$5AE_{18}$	Jensen and Powell upper	Ditch near Taylorville.
$5AE_2$	Lee creek	At Cardston.
$5AE_9$	Pinepound creek	Near Spring Coulee.
$5AE_{16}$	Pothole creek (lower)	At Russell's ranch.
$5AE_{11}$	Pothole creek (upper)	Near Magrath.
$5AE_{17}$	Rolph creek	At Powell ranch.
$5AE_1$	St. Mary river	Near international boundary.
$5AE_6$	St. Mary river	Near Lethbridge.
$5AE_{0.5}$	Swift Current creek	At Many Glaciers.
$5AE_{0.6}$	Swift Current creek	At Sherburne.
$5AG_1$	Taber irrigation District canal	Near Chin.
$5AE_{0.3}$	United States Reclamation Service—St. Mary canal	At Hudson Bay divide.
$5AE_{0.1}$	"	At intake.
$5AE_{0.2}$	"	At. St. Mary crossing.

LITTLE BOW RIVER TRIBUTARY BASIN

Index Number	Stream	Location
$5AC_3$	Little Bow river	Near Carmangay.

BOW RIVER TRIBUTARY BASIN

Index Number	Stream	Location
$5BB_1$	Bow river	At Banff.
$5BM_4$	Bow river	Near Bassano.
$5BH_4$	Bow river	At Calgary.
$5BE_3$	Bow river	At Kananaskis.
$5BD_2$	Cascade river	At Bankhead.
$5AC_4$	C. L. and I. Co.'s canal	Near lake McGregor.
$5CJ_1$	C. P. R. Co.'s canal, north branch	Near Bassano.
$5BM_1$	C. P. R. Co.'s canal, headgates	At Calgary.
$5CJ_3$	C. P. R. Co.'s canal, east branch flume	Near Lathom.
$5CJ_4$	C. P. R. Co.'s canal, Springhill	Near Lathom.
$5BM_3$	C. P. R. Co.'s canal, Springhill	At Ogden.
$5BJ_1$	Elbow river	At Calgary.
$5BJ_3$	Elbow river	At Fullerton's ranch.
$5BL_9$	Highwood river	Near Aldersyde.
$5BE_2$	Kananaskis river	Near Seebe...
$5BL_5$	Little Bow ditch	At High River.
$5BM_5$	Skelton creek	Near Gleichen.
$5BC_1$	Spray river	Near Banff.
$5BC_3$	Spray creek	At Spray lakes.
$5BC_2$	Spray river	At Spray lakes.

REGULAR GAUGING STATIONS—*Continued*

SEVEN PERSONS CREEK TRIBUTARY BASIN

Index Number	Stream	Location
$5AH_{34}$	Denbigh A. G. ditch	Near Ranchville.
$5AH_{38}$	Paradise creek	Near Sevenpersons.
$5AH_{5}$	Sevenpersons creek	At Medicine Hat.
$5AH_{33}$	Sevenpersons creek	Near Sevenpersons.

ROSS CREEK TRIBUTARY BASIN

$5AH_{21}$	Miss A. H. Brown ditch	Near Eagle Butte.
$5AH_{13}$	Bullshead creek	At Johnston's ranch.
$5AH_{22}$	Mrs. M. A. Clark ditch	Near Little Plume.
$5AH_{23}$	B. Dempster ditch	Near Eagle Butte.
$5AH_{24}$	J. Demster ditch	Near Eagle Butte.
$5AH_{14}$	J. K. Drinnan north ditch	Near Medicine Hat.
$5AH_{17}$	J. K. Drinnan lateral ditch	Near Medicine Hat.
$5AH_{16}$	J. K. Drinnan south ditch	Near Medicine Hat.
$5AH_{18}$	J. K. Drinnan south lateral ditch	Near Medicine Hat.
$5AH_{37}$	Gros Ventre creek	At Norton.
$5AH_{3}$	Ross creek	At Irving.
$5AH_{32}$	Ross creek	At Pashley.
$5AH_{11}$	Stark and Burton ditch	From Bullshead creek.

RED DEER RIVER TRIBUTARY BASIN

$5CH_{2}$	Berry creek	Near Wardlow.
$5CH_{3}$	Berry creek east branch	Near Wardlow.
$5CC_{1}$	Blindman river	Near Blackfalds.
$5CE_{2}$	Kneehills creek	Near Drumheller.
$5CE_{1}$	Red Deer river	At Drumheller.
$5CK_{2}$	Red Deer river	At Empress.
$5CC_{2}$	Red Deer river	At Red Deer.
$5CE_{3}$	Rosebud river	At Beynon.
$5CC_{4}$	Sylvan creek	Near Sylvan lake.

SWIFT CURRENT CREEK TRIBUTARY BASIN

$5HD_{15}$	Axton east ditch	Near South Fork.
$5HD_{14}$	Axton north ditch	Near South Fork.
$5HD_{8}$	Axton west ditch	Near South Fork.
$5HD_{27}$	J. S. Green ditch	Near Swift Current.
$5HD_{16}$	G. E. Hawkins ditch	Near Leitchville.
$5HD_{17}$	H. S. Jones ditch	Near East End.
$5HD_{13}$	C. L. Lewis ditch	At Klintonel.
$5HD_{18}$	Parker north ditch	Near South Fork.
$5HD_{19}$	Parker south ditch	Near South Fork.
$5HD_{12}$	D. H. Pollock east ditch	Near South Fork.
$5HD_{10}$	D. H. Pollock west ditch	Near South Fork.
$5HD_{20}$	K. Sinclair ditch	Near Leitchville.
$5HD_{22}$	Stearns Bros. north ditch	Near Leitchville.
$5HD_{21}$	Stearns Bros. south ditch	Near Leitchville.
$5HD_{24}$	C. E. Stearns middle ditch	Near Dollard.
$5HD_{23}$	C. E. Stearns north ditch	Near Dollard.
$5HD_{25}$	C. E. Stearns south ditch	Near Dollard.
$5HD_{5}$	Swift current creek	At Sinclair's ranch.
$5HD_{7}$	Swift current creek	Near Swift Current.
$5HD_{86}$	F. T. White ditch	Near Klintonel.

REGULAR GAUGING STATIONS—*Continued*

Mackenzie River Drainage Basin

SLAVE RIVER TRIBUTARY BASIN

Index Number	Stream	Location
7NB1	Slave river	At Fort Fitzgerald.

PEACE RIVER TRIBUTARY BASIN

Index Number	Stream	Location
7HF1	Peace river	At Fort Vermilion.
7CF1	Peace river	At Hudson Hope, B.C.
7HA1	Peace river	At Peace river.
7GJ1	Smoky river	At Smoky.

ATHABASKA RIVER TRIBUTARY BASIN

Index Number	Stream	Location
7BE1	Athabaska river	At Athabaska.
7AD1	Athabaska river	At Entrance.
7AA2	Athabaska river	At Jasper.
7BF1	East Prairie river	Near Enilda.
7CA3	Flat creek	Near Boyle.
7CA4	Flat creek	Near Donatville.
7BF4	Heart river	Near High Prairie.
7BF3	Iroquois creek	Near Aggie.
7BK1	Lesser Slave river	At Sawridge.
7BB1	Lobstick river	Near Entwistle.
7AG1	McLeod river	Near Wolf creek.
7BB2	Pembina river	At Entwistle.
7AA3	Rocky river	At Hawes.
7AA5	Snake Indian river	Near Bedson.
7BH1	Sucker creek	Near Arcadia.
7BF2	West Prairie river	Near High Prairie.

Mississippi River Drainage Basin

MILK RIVER TRIBUTARY BASIN

Index Number	Stream	Location
11AA0·3	North branch Milk river	Above outlet of U.S.R.S. St. Mary canal.
11AA1	North branch Milk river	Near international boundary.
11AA0·1	South branch Milk river	Near international boundary.
11AA0·2	Milk river	At eastern crossing.
11AA5	Milk river	Milk river.

LODGE CREEK TRIBUTARY BASIN

Index Number	Stream	Location
11AB29	H. T. Clark north ditch	Near Eagle Butte.
11AB30	H. T. Clark south ditch	Near Eagle Butte.
11AB21	English ditch	Near Thelma.
11AB33	Gregg ditch	Near Govenlock.
11AB34	D. A. Hammond ditch	Near Govenlock.
11AB35	J. E. Hart ditch	Near Thelma.
11AB61	Hart north ditch	Near Thelma.
11AB62	Hart south ditch	Near Thelma.
11AB36	Jahn ditch	Near Govenlock.
11AB39	Legge north branch, east ditch	Near Fox.
11AB40	Legge south branch, east ditch	Near Fox.
11AB41	Legge west ditch	Near Fox.
11AB6	Lodge creek	Near international boundary.
11AB42	Lynch ditch	Near Govenlock.
11AB45	McCann ditch	Near Fox.
11AB1	Middle creek	At Down's ranch.
11AB8	Middle creek	At Hammonds ranch.
11AB47	Mitchell lower ditch	Near Thelma.
11AB46	Mitchell upper ditch	Near Thelma.
11AB48	Mitchell Bros. ditch	Near Thelma.

REGULAR GAUGING STATIONS—*Continued*

LODGE CREEK TRIBUTARY BASIN—*Concluded*

Index Number	Stream	Location
$11AB_{49}$	Mock ditch	Near Thelma.
$11AB_{50}$	Mudie ditch	Near Eagle Butte.
$11AB_{55}$	Peachey ditch	Near Govenlock.
$11AB_{57}$	J. Read east ditch	Near Thelma.
$11AB_{56}$	J. Read west ditch	Near Thelma..
$11AB_{59}$	Roth ditch	Near Eagle Butte.
$11AB_{60}$	Spangler M. M. and J. M. ditch	Near Altawan.
$11AB_{63}$	Thelma creek	At English ranch.
$11AB_{63}$	W. Wright ditch	Near Battle Creek.

BATTLE CREEK TRIBUTARY BASIN

Index Number	Stream	Location
$11AB_{26}$	Badger ditch	Near Nashlyn.
$11AB_{27}$	Battle creek	At international boundary.
$11AB_{10}$	Battle creek	At Nash's ranch.
$11AB_{3}$	Battle creek	At Tenmile Police Detachment.
$11AB_{19}$	Gaff ditch	Near Battle creek.
$11AB_{25}$	Gilchrist Bros. ditch	Near Consul.
$11AB_{12}$	Harmon Henderson ditch	Near Battle creek.
$11AB_{37}$	Leslie east ditch	Near Coulee.
$11AB_{38}$	Leslie west ditch	Near Coulee.
$11AB_{43}$	Marchsall and Gaff ditch	Near Battle creek.
$11AB_{44}$	J. McKinnon ditch	Near Consul.
$11AB_{51}$	Mull east ditch	Near Coulee.
$11AB_{52}$	Mull west ditch	Near Coulee.
$11AB_{53}$	E. J. Parsonage ditch	Near Battle creek.
$11AB_{54}$	Patterson ditch	Near Battle creek.
$11AB_{58}$	Richardson L. E. and S. R. ditch	Near Consul.
$11AB_{22}$	Shephered Bros. east ditch	Near Battle creek.
$11AB_{20}$	Shepherdd Bros. west ditch	Near Battle creek.
$11AB_{16}$	Spangler A. M. ditch	Near Coulee.
$11AB_{18}$	Sterling and Nash ditch	Near Nashlyn.
$11AB_{64}$	Wilkes R.W. and W.J. ditch	Near Oxarat.
$11AB_{65}$	Wilson ditch	Near Battle creek.
$11AB_{67}$	Wood and Anderson north ditch	Near Coulee.
$11AB_{66}$	Wood and Anderson south ditch	Near Coulee.
$11AB_{24}$	Wood and Anderson west ditch	Near Coulee.

FRENCHMAN RIVER TRIBUTARY BASIN

Index Number	Stream	Location
$11AC_{30}$	Armstrong east ditch	Near Murraydale.
$11AC_{31}$	Armstrong west ditch	Near Murraydale.
$11AC_{32}$	Barroby ditch	Near Dorrell.
$11AC_{33}$	Bate north ditch	Near Nummola.
$11AC_{34}$	Bate south ditch	Near Nummola.
$11AC_{16}$	Belanger creek	Near Oake's ranch.
$11AC_{21}$	Bolingbroke ditch	Near East End.
$11AC_{35}$	V. J. Bull ditch	Near Ravenscrag.
$11AC_{36}$	Clark and Thompson ditch	Near East End.
$11AC_{20}$	Cross A. M. ditch	Near Dorrell.
$11AC_{12}$	F. Cross ditch	Near Dorrell.
$11AC_{4}$	Davis creek	At Drury's ranch.
$11AC_{25}$	Denniel creek	Near Val Marie.
$11AC_{39}$	T. A. Drury ditch	Near Consul.
$11AC_{5}$	Enright and Strong ditch	Near East End.
$11AC_{3}$	Fairwell creek	At Drury's ranch.
$11AC_{40}$	Frenchman river	At Drury's ranch.
$11AC_{1}$	Frenchman river	At East End.
$11AC_{23}$	Frenchman river	At 50 Mile Crossing.
$11AC_{41}$	Frenchman river	At international boundary.
$11AC_{42}$	Kearney Bros. ditch	Near Kealy Springs.
$11AC_{19}$	Maple Creek Cattle Co. ditch	Near Oxarat.
$11AC_{13}$	Morrison Bros. ditch	Near East End.
$11AC_{43}$	G. N. Morrison ditch	Near East End.
$11AC_{47}$	Pearse ditch	At Ravenscrag.
$11AC_{44}$	J. C. Strong east ditch	At East End..
$11AC_{45}$	J. C. Strong west ditch	At East End.
$11AC_{8}$	Sucker creek	At Gilchrist's ranch.

REGULAR GAUGE STATIONS—*Continued*

ROCK CREEK TRIBUTARY BASIN

Index Number	Stream	Location
$11AE_{0\cdot 1}$	Bowery ditch	Near Barnard Mont.
$11AE_{0\cdot 3}$	Horse creek	Near Barnard Mont.
$11AE_{1}$	McEachern creek	At McCoy's ranch.
$11AE_{0\cdot 2}$	Rock creek	Near Barnard Mont.

MINOR DRAINAGE BASINS

ANTELOPE LAKE BASIN

$5HA_{15}$	Bridge creek	At Gull lake.
$5HA_{39}$	Dimmock Bros. north ditch	Near Dimmock.
$5HA_{40}$	Dimmock Bros. south ditch	Near Dimmock.

BIGSTICK LAKE BASIN

$5HA_{27}$	Adams north ditch	Near Cypress.
$5HA_{28}$	Adams south ditch	Near Cypress.
$5HA_{37}$	Blair ditch	Near Maple Creek.
$5HA_{41}$	Dixon ditch	Near Maple Creek.
$5HA_{60}$	Greely Stewart and Dixon ditch	Near Maple Creek.
$5HA_{46}$	J. Mitchell ditch	Near Bigstick.
$5HA_{19}$	Maple creek	At Dixon's ranch.
$5HA_{50}$	G. Pollock east ditch	Near Cypress.
$5HA_{51}$	G. Pollock west ditch	Near Cypress.
$5HA_{52}$	W. A. Small ditch	Near Cypress.
$5HA_{26}$	A. A. Small ditch	Near Cypress.
$5HA_{57}$	I. H. Williams ditch	Near Maple Creek.
$5HA_{58}$	I. T. Wilson ditch	Near Maple Creek.

BITTERN LAKE BASIN

$5FA_{3}$	Big Hay lake ditch	Near Millet.

CRANE LAKE BASIN

$5HA_{3}$	Bear creek	At Unsworth's ranch.
$5HA_{35}$	Beveridge east ditch	Near Skibbereen.
$5HA_{20}$	Beveridge west ditch	Near Skibbereen.
$5HA_{38}$	Braniff ditch	Near Piapot.
$5HA_{34}$	Cumberland ditch	Near Cardell.
$5HA_{42}$	Fearon ditch	Near Cardell.
$5HA_{33}$	McCarthy, Bertram and Salt east ditch.	Near Piapot.
$5HA_{32}$	McCarthy, Bertram and Salt west ditch.	Near Piapot.
$5HA_{25}$	Moorehead ditch	Near Skibbereen.
$5HA_{17}$	Needham ditch	Near Piapot.
$5HA_{53}$	Tranter north ditch	Near Skibbereen.
$5HA_{54}$	Tranter south ditch	Near Skibbereen.

EAST FORK LAKE BASIN

$11AB_{28}$	I. A. G. Brown ditch	Near Divide.

REGULAR GAUGING STATIONS—*Continued*

GREEN LAKE BASIN

Index	Stream	Location
$11AB_{32}$	Faulkners west ditch	Near Battle Creek.

HAY LAKE BASIN

$5HA_{19}$	Fauquier ditch	Near Maple Creek.
$5HA_{44}$	G. R. Hammond east ditch	Near Maple Creek.
$5HA_{45}$	G. R. Hammond west ditch	Near Maple Creek.
$5HA_{48}$	Peacock east ditch	Near Maple Creek.
$5HA_{49}$	Peacock west ditch	Near Maple Creek.
$5HA_{55}$	Udal east ditch	Near Maple Creek.
$5HA_{57}$	Udal west ditch	Near Maple Creek.

JOHNSTON LAKE BASIN

$5JB_1$	Notukeu creek	Near Vanguard.
$5JC_1$	Wewa creek	Near Gravelbourg.
$5JA_1$	Wood river	Near Gravelbourg.

LAKE OF THE NARROWS BASIN

$5HA_{43}$	Gordon, Ironside and Fares ditch	Near Crane Lake.
$5HA_{31}$	Mann ditch	Near Skull Creek.
$5HA_{47}$	Nicol and Heffer ditch	Near Tompkins.
$5HA_{16}$	Skull Creek	At Doyle's ranch.

LENORE LAKE BASIN

$5KA_5$	Mullner creek	Near Verndale.

MANITOU LAKE BASIN

$5GA_1$	Eyehill creek	Near Yonkers.

PAKOWKI LAKE BASIN

$5AF_9$	Canal creek	At Richardson's farm.
$5AF_{22}$	Greyback coulee	Near Orion.
$5AF_{13}$	Haugan ditch	Near Orion.
$5AF_{12}$	Harms ditch	Near Orion.
$5AF_7$	Ketchum creek	Near Manyberries.
$5AF_{19}$	Kreuger ditch	Near Manyberries.
$5AF_8$	Irrigation creek	At Jacques ranch.
$5AF_{10}$	Manyberries creek	At Brodin's ranch.
$5AF_{14}$	McLean ditch	Near Catchem.
$5AF_{18}$	Roberts ditch	Near Orion.
$5AF_3$	Yeast north ditch	Near Manyberries.
$5AF_5$	Yeast south ditch	Near Manyberries.

PONASS LAKE BASIN

$5LA_1$	Ponass creek	Near Ponass Lake.

REGULAR GAUGING STATIONS—*Concluded*

WILD HORSE LAKE BASIN

Index Number	Stream	Location
$11AA_{16}$	Heydlauffs ditch	Near Sage Creek.
$11AA_{9}$	Sage creek	Near Wild Horse Police Detachment.
$11AA_{19}$	Simpson Bros. east ditch	Near Sage Creek.
$11AA_{21}$	Simpson Bros. north ditch	Near Sage Creek.
$11AA_{20}$	Simpson Bros. west ditch	Near Sage Creek.
$11AA_{17}$	Wiley east ditch	Near Sage Creek.
$11AA_{18}$	Wiley west ditch	Near Sage Creek.

MANY ISLAND LAKE BASIN

$5AH_{18}$	D. Drinnan east ditch	Near Walsh.
$5AH_{19}$	D. Drinnan north ditch	Near Walsh.
$5AH_{20}$	D. Drinnan south ditch	Near Walsh.

MISCELLANEOUS GAUGING STATIONS

SASKATCHEWAN RIVER TRIBUTARY BASIN

	Carrot river	At Skeenes bridge.
		Near Kinistino.
	Marsh canal	Near Kinistino.

ST. MARY RIVER TRIBUTARY BASIN

	Swift Current creek	Near Sherburne.

BOW RIVER TRIBUTARY BASIN

	Fortymile creek	Near Banff.
	Jumping pound creek	Near Jumping Pound.
	Spray river lower station	At Canyon near Spray lakes.

RED DEER RIVER TRIBUTARY BASIN

	Berry creek	Near Carolside.

MACKENZIE RIVER DRAINAGE BASIN

HAY RIVER TRIBUTARY BASIN

	Hay river	Near Alexandra Falls.
	Hay river	Near Hay River (lower).

SLAVE RIVER TRIBUTARY BASIN

	Rocher river	Near Chipewyan.

PEACE RIVER TRIBUTARY BASIN

	Quatre Fourches river	Near Chipewyan.
	Strong creek	Near Shaftesbury.

MISCELLANEOUS GAUGING STATIONS—*Concluded*

ATHABASKA RIVER TRIBUTARY BASIN

Index Number	Stream	Location
....	Lesser Slave river	At Mirror landing.
....	Lesser Slave river	At Saulteux rapids.
....	Maskuta creek	Near Entrance.
....	Snaring river	Near Snaring Junction.

Mississippi River Drainage Basin

BATTLE CREEK TRIBUTARY BASIN

....	Marshall and Gaff ditch	N. E. 33–5–29–3.
....	Sixmile coulee	6–7–28–3.

FRENCHMAN RIVER TRIBUTARY BASIN

....	Chamberlin's coulee	S.W. 4–1–10–3.

Minor Drainage Basins

PAKOWKI LAKE BASIN

....	Pakowki lake	Near Orion.

GAUGING STATIONS WITHOUT DISCHARGE RECORDS

Nelson River Drainage Basin

ASSINIBOINE RIVER TRIBUTARY BASIN

$5NB_5$	Shallow lake	Near Weyburn.

SASKATCHEWAN RIVER TRIBUTARY BASIN

$5KA_2$	Waterhen lake	At Young's farm.

NORTH SASKATCHEWAN RIVER TRIBUTARY BASIN

$5EB_3$	Beaverhill lake	Near Mundare.
$5EB_7$	Cooking lake	Near North Cooking Lake.
$5EB_4$	Hastings lake	Near Deville.
$5EG_3$	Jackfish lake	Near Meota.
$5DE_2$	Lake Wabamun	At Wabamun.
$5EB_5$	Sisib lake	Near North Cooking Lake.
$5EC_1$	Smoky lake	Near Warspite.

BOW RIVER TRIBUTARY BASIN

$5BH_5$	Bow river	Near Cochrane.
$5BD_3$	Lake Minnewanka	Near Bankhead.
$5BC_4$	Spray lakes	At Spray lakes.

GAUGING STATIONS WITHOUT DISCHARGE RECORDS—*Continued*

ROSS CREEK TRIBUTARY BASIN

Index Number	Stream	Location
$5AH_{25}$	Elkwater lake	At Lusk's ranch.

RED DEER RIVER TRIBUTARY BASIN

$5CC_3$	Sylvan lake	Near Sylvan Lake.

Mackenzie River Drainage Basin

ATHABASKA RIVER TRIBUTARY BASIN

$7CA_2$	Flat lake	Near Stocks.
$7BG_1$	Lesser Slave lake	At Granard.

Mississippi River Drainage Basin

FRENCHMAN RIVER TRIBUTARY BASIN

$11AC_{38}$	Cypress lake (north)	Near Consul.
$11AC_{37}$	Cypress lake (south)	Near Consul.

Minor Drainage Basins

BIG LAKE BASIN

$5AC_5$	Big lake	Near High River.

BIGSTICK LAKE BASIN

$5HA_{36}$	Bigstick lake	Near Maple Creek.

BITTERN LAKE BASIN

$5FA_4$	Big Hay lake	Near Millett.
$5FA_3$	Bittern lake	Near Bittern Lake.

JOHNSTON LAKE BASIN

$5JD_1$	Johnston lake	Near Gravelbourg.

LENORE LAKE BASIN

$5KA_6$	Lenora lake	Near Verndale.

LITTLE MANITO LAKE BASIN

$5JJ_1$	Little Manito lake	Near Watrous.

GAUGING STATIONS WITHOUT DISCHARGE RECORDS—*Concluded*

MANITO LAKE BASIN

Index Number	Stream	Location
$5GA_2$	Manito lake	Near Yonker.

MUD LAKE BASIN

$5AB_{11}$	Mud lake	Near Macleod.

PAKOWKI LAKE BASIN

$5AF_{20}$	Pakowki lake	Near Etzikom.

PONASS LAKE BASIN

$5LA_3$	Ponass lake	Near Ponass Lake.

QUILL LAKE BASIN

$5MA_2$	Quill lake	Near Clair.
$5MA_3$	Quill lake	Near Quill Lake.

RANCH LAKE BASIN

$5MA_4$	Ranch lake	Near Lenore Lake.

SULLIVAN LAKE BASIN

$5CF_1$	Sullivan lake	Near Sullivan lake.

THOMAS LAKE BASIN

$5FB_1$	Thomas lake	Near Viking.

WILLOWBUNCH LAKE BASIN

$11AF_1$	Willowbunch lake	Near Viceroy.

POWER AND STORAGE INVESTIGATIONS

The power and storage investigations in the provinces of Alberta and Saskatchewan were carried out under the joint direction of Mr. C. H. Attwood, district chief engineer at Winnipeg, and the undersigned. In this manner the direct personal knowledge of power questions in these provinces which was obtained by Mr. Attwood during the number of years he had them under his charge, was taken advantage of. At the same time the direct control of the district chief engineer at Calgary proved of value in questions calling for immediate action or continued field inspection.

The power activities included:—

1. Taking over and operating lake Minnewanka storage during the season of filling the reservoir.

2. Co-operation with the Winnipeg office in sending a party for power investigations in the district of MacKenzie.

3. Further investigations at Bow Falls power site.

4. Co-operation with the Calgary Power Company engineers in an investigation of Cascade River power possibilities.

5. Investigations of three applications for use of power site on Crowsnest river.

6. Investigation of proposed use of Belly river for power in connection with grist mill.

7. Special office study of the power possibilities of Bow river and its tributaries above Calgary.

Operation of Lake Minnewanka Storage.—In 1912 after complete surveys had been made, a storage reservoir was created at lake Minnewanka by the placing of a dam at the head of Devil's canyon on Cascade river. This has permitted the storage of flood waters of Cascade river for use in augmenting the low-flow of Bow river at the plants of the Calgary Power Company situated at Kananaskis falls and Horseshoe falls about thirty miles below the mouth of Cascade river.

In the spring of 1921 this branch was requested to take over from the Calgary Power Company the operation of lake Minnewanka storage during the filling season as it was considered that such action would be in the interests of the public. On April 23, the branch assumed the responsibility for the filling of the reservoir, it being understood this operation should be completed before the opening of the tourist season in Rocky Mountain Park, which is about July 1. On June 12, the lake had been raised to a level sufficient to cover the unsightly mud flats and on June 25 it was brought to upper regulation level.

Another improvement brought about through the co-operation of the Dominion Water Power Branch and the Dominion Parks Branch was the cleaning up of the unsightly surroundings of the dam at the outlet of lake Minnewanka storage basin. While the work was carried out by the Calgary Power Company, the initiative in starting and the oversight of the work was left in the hands of the Dominion Water Power Branch. The work was accomplished to the satisfaction of the Dominion Parks Branch officials. The results of our operations in this area has been a great improvement in the appearance of one of the beauty spots of our National Parks.

MacKenzie District Survey.—On March 28th, 1921, acting on instructions received from the director, Mr. Attwood and the undersigned met at Winnipeg to discuss the organization of a party for power surveys in the district of MacKenzie.

The following party left Edmonton in April and proceeded north via Peace river for the purpose of making surveys on Slave river at Slave falls and on Hay river at Alexandra Falls; engineer in charge, D. B. Gow; assistant engineers, H. L. Johnston and C. C. Planche; assistants, R. D. Barnetson, H. A. Blake, T. D. Burt and a cook. The first two named above were from the Winnipeg office, the other four from the Calgary office. The party was some five months in the field. The surveys having been under the charge of Mr. Gow of Mr. Attwood's office, the reference to the results obtained will be shown in the latter's portion of this Annual Report.

Bow Falls—Bow Falls are situated immediately above the confluence of the Spray and Bow rivers in the village of Banff and afford a splendid site for a power development. This site has been surveyed and was reported upon in 1916 when development was recommended with the intake, tunnel, and power house situated on the right bank. In 1920 a survey was made on the left bank as it appeared that a development on that side of the river offered advantage from the aesthetic viewpoint. In 1921, as the Dominion Parks Branch for whom the surveys were being made was considering the commencement of work on the development on the left bank, more intensive topography was obtained and the survey brought to the point where the tunnel and power-house site could be finally staked out at a few days notice.

Cascade River.—As has been stated above under the head of lake Minnewanka storage, the flood waters of the Cascade river have been since 1912 stored in that reservoir and used for augmenting the flow of the Bow river at low-water periods which occur during the times of minimum temperature. In an endeavor to increase their power output during these periods of low-flow, the Calgary Power Company made a reconnaissance survey of the power possibilities of the lower Cascade river. Our engineers co-operated in the field with those of the company and the complete plans incorporating the data secured will be filed with the department.

Crowsnest Falls Site.—Three applications have been received during the year for the development of this site which is located on Crowsnest river in Section 28, Township 7, Range 2, West 5th Meridian, about two miles from the town of Lundbreck. A survey of this site was made in 1917 by Mr. C. H. Attwood for the Dominion Water Power Branch. The report on this survey has proved of great value in considering these further applications.

During the year a new phase of water-power development in southern Alberta has arisen. This is the development of water-power to be used in connection with irrigation projects to lift water to higher levels to place on the land and to operate small plants such as grist mills for the advantage of the irrigators.

FLOOD WARNING SERVICES.

The annual survey of the snow fields at the headwaters of the Bow river was made in May and June. This survey was inaugurated in the year following the floods of 1915 and is used, together with the records of flood gauges, for giving flood warnings along streams flowing from the mountains.

ABSORPTION LOSSES INVESTIGATIONS AT LAKE NEWELL.

Mr. Charles McGavin continued the special seepage and evaporation losses investigation of the Canadian Pacific Railway, Department of National Resources reservoir, Lake Newell, which was commenced in 1920. Intensive stream measurement work was carried on at the inlet and outlet canals, evaporation, temperatures, wind velocities and other necessary records were kept and a full report submitted to the Acting Commissioner of Irrigation at whose request the investigation was made.

CURRENT METER RATING STATION

The only constructed current meter rating station in Canada is located in Calgary. At this station all meters sent in by those making stream measurements in Canada are rated upon receipt, and after being placed in repair, rerated. Rating tables are returned to the owners along with their meters. During the year ending March 31, 1922, 104 meters were rated of which one was for the

Maritime Provinces district, fourteen for the Ontario district, eight for the British Columbia district, ten for the Manitoba district, and forty-nine for the Alberta and Saskatchewan district of the Dominion Water Power Branch, three for the British Columbia Water Rights Branch, six for the Canadian Pacific Railway Company, one for the Canada Land and Irrigation Company, and one for Instruments Limited at Ottawa. In addition to the above mentioned 104 ratings, there were also made a number of experimental ratings with new designs of meters and of old designs under different conditions. Reports on these experimental ratings were prepared.

ARTHUR L. FORD,
District Chief Engineer.

DISTRICT OF MANITOBA

During the fiscal year ending March 31, 1922, the regular stream measurement and power investigatory operations of the Dominion Water Power Branch in Manitoba and adjacent districts have been continued.

The scope of the work covered by this district organization comprises the power survey and storage investigatory work in Manitoba, Saskatchewan and Alberta, and the hydrometric work in the province of Manitoba and in that portion of western Ontario inclusive of and lying to the west of the Nipigeon river.

ORGANIZATION.

The local organization of the Dominion Water Power Branch, headquartered at 231 Chambers of Commerce, Winnipeg was organized in 1912, and the work then instituted has since been carried on and extended from time to time. The duties of the engineers and the hydrometric recorders consist of both field and office work, including surveys, investigations and preparation of data collected in report form for submission to head office.

CO-OPERATION.

The organization works in co-operation with several departments of the Federal and Provincial Governments, particularly the Public Works Department and the Reclamation Service of the Federal Government, and the Power Commission and the Drainage Commission of Manitoba.

HYDROMETRIC SURVEY.

In addition to the regular stations being maintained, gauge readings were secured on a number of the smaller streams in southern Manitoba, in connection with drainage problems.

On the Winnipeg river, the gauges at the head of Whitemud falls, head and foot of Silver falls, and head and foot of Pine falls, were discontinued, as it was considered that sufficient records had been obtained to determine the maximum and minimum stages.

The winter of 1920-21 was mild with average precipitation. Break-up generally occurred throughout the district during the middle two weeks of April. A great deal of snow disappeared during March and consequently the streams did not reach high stages during break-up.

The precipitation during the summer and fall was about normal with a corresponding average run-off, with the exception that during the first part of July a very severe storm accompanied by heavy rainfall swept across the southern

part of Manitoba. In drainage district No. 2, lying to the south of the Assiniboine river, the ditches in the low-lying areas were unable to carry away the water brought down from the higher land, with the result that large areas of agricultural land were completely flooded and portions of the crop destroyed.

The winter of 1921-22 following was of average length and severity, freeze-up generally occurring about the middle of November; thought the precipitation was not great the run-off was fairly high. A point of interest is that during the past winter the discharge of the Saskatchewan river at The Pas was almost double that of the previous winter, while at Edmonton and Saskatchewan on the North and South Saskatchewan respectively the discharge was the lowest recorded for some time.

The first half of March of the present year being quite mild, a great deal of snow disappeared, and though two severe snow storms occurred during the latter half of the month it is not anticipated that high stages of the streams will be reached during break-up. In the drainage districts lying to the south, accumulated ice and snow in the ditches and in the culverts, prevented them from carrying off the surface water, consequently in some parts of the lower districts the lands were partially flooded, but little or no damage was done.

The following is a summary of the hydrometric work from April 1, 1921, to March 31, 1922.

REGULAR GAUGING STATIONS

MANITOBA

Sta. No.	Stream	Location
5MH1	Assiniboine	Brandon.
5MJ1	Assiniboine	Headingly.
5ME1	Assiniboine	Millwood.
5RD1	Berens	Above Little Grand rapids.
5ME2	Birdtail creek	Birtle.
5OF3	Boyne	Near Carman.
5OF4	Boyne channel	Near Homewood.
5SA1	Brokenhead	Sinnot.
5OF5	Elm creek	Kenyon's farm.
5LM1	Fairford	Fairford.
5OG1	La Salle	Sanford.
5RA1	Manigotagan	Above Wood falls.
5MF1	Minnedosa	Beilby's bridge.
5MF2	Minnedosa	Minnedosa power house.
5MF3	Minnedosa	Elphinstone.
5LJ2	Mossy	Wilson's farm.
5LJ3	Ochre	Ochre river.
5OA1	Pembina	Killarney.
5OB1	Pembina	La Rivière.
5OB3	Pembina	Manitou.
5BF3	Pinawa channel	Below control dam.
5OE1	Rat	Otterburne.
5OC1	Red	Emerson.
5OC3	Red	Elm Park bridge.
5OJ1	Red	Redwood bridge.
5MF8	Rolling	C.N.R. crossing.
5OD1	Roseau	Baskerville's farm.
5OD4	Roseau	Stuartburn.
5KJ1	Saskatchewan	The Pas.
5OH1	Seine	Ste. Anne des Chênes.
5MD1	Shell	Assessippi.
5MD2	Shell	Steel bridge, south of Roblin.
5NG1	Souris	Wawanesa.
5NF1	Souris	Melita.
5LE1	Swan	Swan river.
5OB2	Tobacco creek	North of Roland.
5LJ4	Valley	Valley River.
5PH1	Whitemouth	Whitemouth.
5OA2	Whitemud	Holmfield.
5PF1	Winnipeg	Above Slave falls.
5PF5	Winnipeg	Head of Grand du Bonnet falls.
5PF6	Winnipeg	Between 4th and 5th falls, Seven Sisters.

REGULAR GAUGING STATIONS

Saskatchewan

Sta. No.	Stream	Location
$5UM_1$	Qu'Appelle	Tantallon.

Ontario

$2AB_1$	Dog	Near Dona.
$5QD_3$	Eagle	Eagle river.
$5QE_1$	English	Ear falls.
$5QA_1$	English	Sioux Lookout.
$5PE_1$	Lake of the Woods	East branch, Kenora power house.
$5PE_2$	Lake of the Woods	West branch, Norman traffic bridge.
$5PE_3$	Lake of the Woods	Mill "A"—headrace.
$5PE_4$	Lake of the Woods	Mill "C"—headrace.
$5PE_5$	Lake of the Woods	Old K.L.M. Co.'s bridge.
$5PE_8$	Lake of the Woods	North Tunnel Island.
$2AB_2$	Mattawin	Near Kaministikwia.
$2AD_2$	Nipigon	Cameron falls.
$2AA_1$	Pigeon	International bridge.
$5PB_1$	Seine	Skunk rapids.
$5PB_2$	Turtle	Mountain rapids.
$5QD_2$	Wabigoon	Near Quibell.
$5PE_{10}$	Winnipeg	Whitedog falls.

MISCELLANEOUS GAUGING STATIONS

Manitoba

$5RD_2$	Berens	Below 1st falls.
$5RD_3$	Berens	Below Night Owl falls.
$5RB_2$	Bloodvein	1st rapids.
$5SD_1$	Lea's creek	Bull Head, lake Winnipeg.
$5OF_2$	Morris	Rosenort.
$5UD_1$	Nelson	Eve's falls.
$5UD_2$	Nelson	Below Whitemud channel.
$5UD_3$	Nelson	Ebb and Flow channel.
$5UD_4$	Nelson	Above Whitemud falls.
$5RD_5$	Pigeon	Above 1st falls.
$5RD_4$	Pigeon	Above Shining falls.
$5RE_1$	Poplar	Above 1st falls.
$5LC_2$	Red Deer	Outlet Red Deer lake.
$5LC_3$	Red Deer	10 miles above mouth.
$5KL_1$	Saskatchewan	Head of Grand rapids.
$5OB_2$	Shannon creek	Kronsgart.
$5MD_3$	Shell	Burrows bridge, Roblin.
$5RA_{10}$	Wanipigow	Below 2nd rapids.
$5MF_9$	Whirlpool	Danvers.
$5LC_4$	Wilson creek	Barrows.
$5LC_5$	Woody creek	Barrows.

Saskatchewan

$6EA_1$	Churchill	Above Attik rapids.
$6CB_1$	Rapid	Outlet of Rabbit lake.
$6DD_1$	Reindeer	Above Deer rapid.
$5KG_1$	Sturgeon-weir	Outlet Wood lake.
$5KG_2$	Sturgeon-weir	Outlet Deschambault lake.
$5KG_3$	Strugeon-weir	Scoop rapids.
$5KG_4$	Sturgeon-weir	Outlet Beaver lake.

MISCELLANEOUS GAUGING STATIONS—Concluded

ONTARIO

Sta. No.	Stream	Location
5QA	Amik	Junction with English river.
5QA	Dog	Below Ghost falls.
5QA	English	Above Amik.
5QA	English	Outlet of Pine lake.
5QA	Gull	Above junction with English river.
$2AB_1$	Kaministikwia	Kakabeka falls.
5QA	Kukukus Lake outflow	At Inlet to Flying Loon lake.
$5PA_1$	Namakan	Outlet Lac la Croix.
$5PA_2$	Loon	Below Loon lake.
$2BB_1$	Pic	Near Heron Bay.
$2AA_1$	Pigeon	International bridge.
5QA	Rice	Outlet of Hut lake.
$2BA_1$	Steel	Near Sancoy.
5QA	Sturgeon	Superior Junction.
5QA	Sturgeon	2nd falls.
5QA	Sturgeon	11th falls.

GAUGING STATIONS WITHOUT DISCHARGE RECORDS

MANITOBA

Sta. No.	Stream or Lake	Location
$5MJ_1$	Assiniboine	Portage la Prairie.
$5MJ_2$	Assiniboine	Fortier.
$5RD_1$	Berens river	Lake Winnipeg.
$5RD_2$	Family lake	Little Grand rapids.
$5LL_1$	Manitoba lake	Delta.
$5UB_1$	Nelson river	Norway House.
$5UD_1$	Nelson river	Cross lake.
$5PF_{40}$	Pinawa channel	Automatic gauge above control dam.
$5SB_1$	Winnipeg lake	Winnipeg Beach.
$5PF_2$	Winnipeg river	Forebay, Point du Bois.
$5PF_3$	Winnipeg river	Tailrace, Point du Bois.
$5PF_{11}$	Winnipeg river	Head of Seven Sisters falls.
$5PF_{22}$	Winnipeg river	City tramway bridge, Lac du Bonnet.
$5PF_{27}$	Winnipeg river	Head of Whitemud falls.
$5PF_{28}$	Winnipeg river	Head of Silver falls.
$5PF_{30}$	Winnipeg river	Head of Pine falls.
$5PF_{31}$	Winnipeg river	Foot of Pine falls.
$5PF_{32}$	Winnipeg river	Fort Alexander.
$5LH_1$	Winnipegosis lake	Winnipegosis.

ONTARIO

2AB	Dog lake	Source of Dog river.
$5QA_2$	English river	Hunt.
$5QB_4$	English river	Pine Ridge H.B. post.
$5PA_1$	Lac la Croix	Portage to Loon lake.
$5PE_1$	Lake of the Woods	Headrace, Norman dam.
$5PE_2$	Lake of the Woods	Tailrace, Norman dam.
$5PE_4$	Lake of the Woods	D.P.W. lake Gauge.
$5PE_6$	Lake of the Woods	Automatic gauge, Kenora.
$5QB_3$	Lac Seul	Hudson's Bay post.
$5QB_2$	Lost lake	Hudson.
$2AD_1$	Nipigon river	Below Cameron's pool.
$2AD_3$	Nipigon lake	Orient Bay.
$2AD_4$	Nipigon river	Camp Alexander.
5QA	Sturgeon river	Near Smith, C.N.R.
$5PE_5$	Winnipeg river	Automatic gauge, Keewatin.
$5PE_9$	Winnipeg river	Minaki.

POWER INVESTIGATIONS

Power and storage investigations were carried out during the year by this district organization in (*a*) The Mackenzie district, (*b*) In Manitoba, (*c*) In the English river basin in Ontario, and in co-operation with the district office in Calgary, in the province of Alberta.

In the Mackenzie district a reconnaissance power survey was made of Smith rapids on the Slave river, and of Alexandra and Louise falls on the Hay river. A personal inspection was also made of the Mackenzie river down to Norman and the lower 35 miles of the Great Bear river. In connection with the above survey, hydrometric observations were made on the Hay, Slave, Peace, Rocher and Quatre Fourches rivers.

Rocher and Quatre Fourches.—The Rocher river and the Chenal des Quatre Fourches are the two outflow channels from lake Athabaska. The Rocher river heads in the northwesterly angle of lake Athabaska and is the main outlet. The Quatre Fourches, heading in the western extremity of the lake, connects lake Athabaska with the Peace river. Under ordinary flow conditions the Quatre Fourches is an outflow channel, but during the period of high water conditions on the Peace river the direction of flow is reversed, with Peace river water flowing into the lake. Occasionally this condition also obtains on the Rocher river.

Both the Rocher and Quatre Fourches traverse a low-lying country with extensive areas of low swampy lands lying between rocky ridges. In September, 1921, the discharge of the Rocher was 93,725 c.f.s., while that of the Quatre Fourches was 9,774 c.f.s.

Slave River.—The Slave river connects the Peace and Rocher rivers with Great Slave lake and drains an area of some 232,000 square miles. The total length of the river is approximately 285 miles. Throughout the first 70 miles of river, extending to Fitzgerald, the river flows with a uniform current averaging about 3 miles per hour, and between banks averaging about 15 feet in height. Below Fitzgerald the river is broken by a series of rapids extending for nearly 18 miles, known as Smith rapids. Fort Smith is situated on the left river bank at the foot of the rapids. Between Fort Smith and Great Slave lake no further rapids occur.

The total drop in the Smith rapids is 111 feet, the greater portion of which could be utilized for the development of power. The discharge of the river recorded between May and September varied from 193,000 c.f.s. to 324,000 c.f.s. Based on an estimated run-off of 0·11 second feet per square mile for ordinary minimum flow, and 0·25 second feet per square mile for maximum development, the power available at Smiths rapids at ordinary minimum flow is 257,000 horse-power and the estimated maximum development is 585,000 horse-power.

Hay River.—The Hay river is the largest tributary flowing into the western portion of Great Slave lake and drains an area of approximately 21,000 square miles. Very little data are available relating to the upper portion of the watershed.

One mile above Alexandra falls, which are situated about 45 miles from the mouth of the river, the river maintains an average width of about 400 feet; the banks are quite steep, frequently vertical cliffs 15 to 20 feet in height and composed of hard limestone overlain with light soil and thickly wooded with poplar and spruce. At Alexandra falls the river plunges with a sheer drop of 105 feet into the gorge below. The river then flows swiftly but smoothly in the limestone gorge about 175 feet deep, for a distance of 1¼ miles to the crest of Louise falls, over which it makes a leap of 41 feet into the deeper gorge below. Below Louise falls the gorge reaches a maximum depth of about 240 feet and continues for nearly 5 miles before widening and flattening out.

These two waterfalls offer very favourable sites for power development and the estimated power available at ordinary minimum flow is 27,500 horse-power, while the estimated maximum development is 82,500 horse-power.

Mackenzie River.—The Mackenzie River drainage system is one of the largest on the North American continent, embracing such large river systems as the Peace, Athabaska, Liard and Great Bear. This drainage area is estimated at 660,000 square miles and has a wide variation of physical features. Mackenzie river has its source in Great Slave lake, from which it flows in a northwesterly direction for a distance of about 1,000 miles before discharging into the Arctic ocean. The river flows out of the western extremity of the lake through two main channels past Big island; the width of the river being about 10 miles. Below Big island and down to the Liard river the Mackenzie varies from one-half of a mile to two miles in width, depending on the number and size of islands in the stream, but below the Liard the river is not less than one mile in width.

The river flows with a current averaging between three and four miles per hour, and is navigable throughout its entire length. There are no natural power sites on the river.

Great Bear River.—The Great Bear river discharges the drainage of Great Bear lake into the Mackenzie river about one mile below Norman, and has an estimated area of 50,000 square miles, of which Great Bear lake has an area of 11,000 square miles. The river, which is about 70 or 75 miles in length, leaves the lake through a comparatively wide shallow channel, flowing westerly over a rock bottom, and for a distance of about 7 miles continues swift, flowing between high banks and stony beaches.

The rapids, so called, commence at a point about 28 miles below the lake. These are merely swift water, flowing over a fairly wide and shallow river section strewn with boulders. The rapids are about four miles in length with a total drop of some 12 or 15 feet, and a width varying from 600 to 1,000 feet. About 2½ miles from the head of the rapids the river cuts through the Franklin mountains; the right bank at this point being rock and almost a precipice several hundred feet high, while the left bank is clay, forest covered, and rising on a slope of approximately 1 to 3.

In August, 1921, the discharge of the river was estimated at 35,000 c.f.s., but owing to the lack of available power data no estimate can be made of the power possibilities of the river at present.

Birdtail Creek—In June last, at the request of the mayor and council of the town of Birtle, the writer and the Manitoba Power Commissioner investigated the possibility of developing power on the Birdtail creek at Birtle and installing an hydro-electric system in the town. An examination of the conditions existing at Birtle, together with a study of the run-off records led to the conclusion that the development of hydro-electric power as a source of light and power for the municipality was neither feasible nor economical.

Upper English Watershed—During the latter part of the summer a reconnaissance survey was made of the upper portion of the English river from Lost lake to the headwaters, and of the Sturgeon river in order to secure reliable power and hydrometric data of the Upper English River basin.

The results of the survey show that the total drop of the English river between lake Minnitaki and Pine lake is 165 feet. One hundred feet of this drop can possibly be developed at four power sites, and possibly 14 feet may be utilized in storage reservoirs.

The total power possibilities at the four sites mentioned at ordinary minimum flow is 8,040 horse-power, while the estimated maximum development is

12,300 horse-power. The largest and most feasible site is at the first rapids above lake Minnitaki, where the possible development at ordinary minimum flow is 2,700 horse-power, and the estimated maximum development is 4,120 horse-power.

The Sturgeon river has a total drop of 173 feet. Of this some 128 feet may be developed at five power sites. The total possible power output of these five sites is 3,600 horse-power with ordinary minimum flow and 5,515 horse-power for maximum development.

CONSTRUCTION.

During the year the extension to the Point du Bois power house of the city of Winnipeg Hydro-Electric System was completed and three new generating units of 6,500 kv.a. each were installed, together with the necessary transformers and switches. A central pumping oil plant was also installed. The new steel tower transmission line was also completed; the transmission line now consisting of four lines on two sets of steel towers built along a private right-of-way.

Active construction of the Great Falls development on the Winnipeg river by the Manitoba Power Company Limited, after considerable preliminary study and investigations, was commenced last fall. Work is now well under way and going ahead rapidly. Excellent camp quarters for the large force of men necessary for the work have been constructed, including mess-halls, and kitchens, bunk-houses, and hospital, together with administration buildings and offices. A complete construction plant has been erected, including rock-crushing plant, concrete chuting equipment, storehouses, machine, blacksmith and carpenter shops, and a complete yard and track layout for the handling of large quantities of material involved in the work.

A 60,000-volt, double-circuit steel-tower transmission line, 18 miles in length, has been constructed from a point on the Pinawa-Winnipeg line of the Winnipeg Electric Railway Company to the power site and connection has been made to the city of Winnipeg Hydro-Electric System line for power supply during construction. This line will ultimately form one link of the permanent transmission system connecting the new development with the existing water-power plant on the Pinawa channel and with the substations in the city of Winnipeg. All the construction plant is now being operated electrically.

During 1921 the Manitoba Power Commission extended the provincial transmission system by constructing a steel-tower single-circuit 66,000-volt branch line, some 50 miles in length, tapped off the Winnipeg-Portage la Prairie line at Oakville, to supply power to Carman and Morden. A 22,000-volt steel-pole line, 3½ miles in length, was also constructed and tapped off the Oakville-Carman line at Jordan to supply power to Roland.

PUBLICATIONS

The results of the stream measurement work carried on by this organization for the climatic year 1919-20 will be published shortly as Water Resources Paper No. 31. The results of the hydrometric work for the climatic year 1920-21 are in course of preparation and will be published as Water Resources Paper No. 36.

C. H. ATTWOOD,
District Chief Engineer.

DISTRICT OF ONTARIO

During the fiscal year ending March 31, 1922, the regular stream measurement and power investigatory operations of the Dominion Water Power Branch in the province of Ontario have been continued, consistent with the terms of the co-operative agreement effective under date of October 1, 1919, between the Department of the Interior and the Hydro-Electric Power Commission of Ontario.

ORGANIZATION

While the work in Ontario has continued under the direction of a central office at Ottawa, changes, which will permit of greater economy, were effected during the year in the field of organization and particularly that of suboffices. In August, 1921, arrangements were made whereby the suboffice at Markdale was closed and the field work of this office apportioned between the main office at Ottawa and the suboffice at North Bay. As in the previous year, all hydrometric investigations in the province to the west of the Nipigon river were under the direction of the district office at Winnipeg.

CO-OPERATION

In pursuing the field and office investigations, the closest co-operation has been maintained with the officers of the Hydro-Electric Power Commission. Valuable assistance has also been given the engineers of the district by various persons and corporations interested in the securing of hydrological data. In particular, reference should be made to the co-operation carried on with the following companies: The Abitibi Power and Paper Company, the Algoma Power Company, the Algoma Steel Corporation, the Mattagami Pulp and Paper Company, the Mississippi River Improvement Company, the Spanish River Pulp and Paper Company, and the International Nickel Company.

HYDROMETRIC SURVEY

All gauging stations were kept in operation and sufficient discharge measurements secured to define the range in flow. To meet the demands of prospective power users, the scope of the work was again extended westward along the line of the Canadian National railway to include certain rivers in the James Bay drainage.

Normal run-off conditions were on the whole encountered in the year, though, in certain watersheds the run-off was extremely low during the autumn months.

Following the decision in December 1921 of the Temiskaming and Northern Ontario Railway Commission to investigate the possibility of electrifying the railway through the utilization of hydro-electric power, a report covering streamflow and power data of the rivers contiguous to the railway was prepared and furnished at the request of the consulting engineers to the commission.

The following summary covers the stations in active operation and those at which occasional records are secured:—

REGULAR GAUGING STATIONS

Station Number	River	Location
$4MC_1$	Abitibi	Iroquois falls.
$2CE_2$	Aux Sable	Massey.
$2FB_1$	Beaver	Eugenia.
$2FB_3$	Beaver	Kimberley.
$2EC_2$	Black	Washago.
$2JC_3$	Blanche (west branch)	Charlton.
$2JC_1$	Blanche (west branch)	Englehart.
$2KC_3$	Bonnechere	Renfrew.
$2HB_1$	Credit	Cataract Junction.
$2AB_1$	Dog	Dona.
$5QD_3$	Eagle	Eagle River.
$5QE_1$	English	Ear falls.
$2GA_1$	Grand	Belwood.
$2GB_1$	Grand	Brantford.
$2GA_2$	Grand	Conestogo.
$2GA_3$	Grand	Galt.
$2GB_2$	Grand	York.
$4LD_1$	Groundhog	Fauquier.
$4JA_1$	Kabinakagami	Kabina.
$4LF_1$	Kapuskasing	Kapuskasing.
$2KD_1$	Madawaska	Madawaska.
$2EA_5$	Maganatawan (north branch)	Burk's falls.
$2EA_6$	Maganatawan (south branch)	Burk's falls.
$2BD_1$	Magpie	Steep Hill falls.
$4LB_1$	Mattagami	Smooth Rock falls.
$2AB_2$	Mattawin	Kaministikwia.
$2BD_2$	Michipicoten	High Falls.
$4LJ_1$	Missinaibi	Mattice.
$2CC_4$	Mississagi	Mississagi.
$2KF_6$	Mississippi	Appleton.
$2KF_7$	Mississippi	Ragged chute.
$2HL_1$	Moira	Foxboro.
$2JD_2$	Montreal	Elk Lake.
$2BE_1$	Montreal	A. C. Ry. bridge, mile 91.
$2EB_2$	Muskoka (south branch)	Black's bridge.
$2EB_4$	Muskoka (north branch)	Port Sydney.
$4JC_1$	Nagagami	Ameson.
$2HM_1$	Napanee	Napanee.
$2AD_4$	Nipigon	Nipigon.
$2GA_{10}$	Nith	Canning.
$2KB_1$	Petawawa	Petawawa.
$2AA_1$	Pigeon	International bridge.
$2FC_4$	Rocky Saugeen	Traverston.
$2FC_5$	Rocky Saugeen	Markdale.
$2FC_1$	Saugeen	Port Elgin.
$2FC_2$	Saugeen	Walkerton.
$2DD_2$	South	Cox's chute.
$2DD_1$	South	Powassan.
$2CE_4$	Spanish	High Falls.
$2GA_8$	Speed	Hespeler.
$2DC_2$	Sturgeon	Smoky falls.
$2FB_7$	Sydenham	Owen Sound.
$2LA_1$	Tay	Glen Tay.
$2GE_1$	Thames (main stream)	Kilworth.
$2GD_3$	Thames (north branch)	Fanshawe.
$2GD_1$	Thames (south branch)	Ealing.
$5PB_2$	Turtle	Mountain rapids.
$2CF_2$	Vermilion	Aho's farm.
$5QD_2$	Wabigoon	Quibell.
$2DB_2$	Wanapitei	McVitties.
$2KD_2$	York	Bancroft.

GAUGING STATIONS WITHOUT DISCHARGE RECORDS

Station Number	Lake or River	Location
$5QB_3$	Lac Seul	Automatic gauge, Hudson Bay post.
$5QB_4$	Lac Seul	Pine Ridge.

MISCELLANEOUS GAUGING STATIONS

Station Number	River	Location
$2FB_6$	Armstrong creek	Markdale.
	Black	Matheson.
$2JC_2$	Blanche	Sauter's bridge.
	John creek	Above Big Eddy dam.
$2AD_1$	Nipigon	Nipigon.
$2BB_1$	Pic	Heron Bay.
	Spanish	Eagle Rock.
$2CE_3$	Spanish	Webbwood.
$2BA_1$	Steel	Santoy.

POWER INVESTIGATIONS.

No extensive power surveys were carried out during the year. Power investigations were confined to collecting and compiling data from public and private sources relating to the power resources of the province.

CONSTRUCTION.

Hydro-electric construction in the province of Ontario has been very extensive during the past year both in the field of public and private undertakings. Under the former class has been the following work of the Hydro-Electric Power Commission of Ontario:—

Queenston-Chippawa Development.—Construction of control works and of the nine-mile intake canal was completed in the month of December and the canal filled with water for the first time. In the following two months two 60,000-horsepower units were placed in operation while work leading to the installation of the remaining three units of similar capacity of the projected initial installation has since been in progress.

Cameron Falls Development—Pending the completion of the main control dam, this plant on the Nipigon river was placed in operation in 1920 under a partial head. Construction of the main dam was finished during 1921 thereby permitting the initial installation of two 12,500-horsepower units operating under the full head of 77 feet.

Ranney's Falls Development—Construction of this 10,000-horsepower plant on the Trent river near Campbellford was continued throughout the year.

Construction on the part of private interests has included the following projects:—

Twin Falls Development—Construction of this plant by the Abitibi Power and Paper Company, a short distance below the outlet of lake Abitibi on the Abitibi river was completed in the latter part of 1921. Through it the dam at the lake outlet is superseded and lake level and outflow directly controlled. The installation consists of four 6,000-horsepower units operating under a normal

head of 60 feet with provision in the power-house for a fifth unit of similar capacity.

Smoky Falls Development—This development of the Spanish River Pulp and Paper Company on the Sturgeon river has been completed with an installation of two 2,600-horsepower units operating under a head of 35 feet. The power developed is transmitted a distance of 10 miles to the Sturgeon Falls mill of the company.

Cornwall Development—This plant of the Canadian Cottons, Ltd., intakes off the Cornwall canal and was completed in 1921. The installation consists of three 1,500-horsepower units operating under a head of 24 feet.

Other than the new developments above noted, enlargements made during the year to existing power developments include a 250-horsepower unit in the plant of the Lincoln Paper Mills at Merritton on the Welland canal and three 2,400-horsepower units in the power-house of the Great Lakes Power Company in the St. Mary river at Sault Ste. Marie. The enlargement of the Kenora Municipal plant to permit of an additional installation of 4,800-horsepower was also in progress during the year.

Various power projects which are now the subject of investigation would indicate that there is very good prospect of continued construction. Other than the possible electrification of the Temiskaming and Northern Ontario railway, the immediate demand for increased power in the Porcupine mining district has given rise to several schemes of power development. At the same time the pulp and paper industry has been active and there is every possibility of further development both in northern and western Ontario. In connection with all such projects it is particularly worthy of note that accurate stream-flow data is an essential factor to their consideration and as a consequence there has been an extensive demand for the records of the branch.

ST. LAWRENCE RIVER NAVIGATION AND POWER SCHEME

In conformity with the reference made to the International Joint Commission by the Governments of Canada and the United States for an investigation of the feasibility and desirability of the development of the St. Lawrence river in the interests of navigation and power, the consulting engineers to the commission completed their investigation and in July 1921 presented their final report. In it a combined navigation and power scheme of development was recommended. At a public hearing subsequently held by the International Joint Commission alternative proposals of combined development were advanced by the Hydro-Electric Power Commission of Ontario, by Hugh L. Cooper and Co. of New York and by the New York and Ontario Power Company. On December 19, 1921, the commission presented their final report in which they approved of the feasibility and desirability of a combined scheme of development but recommended that the engineering details of the scheme be referred for investigation and final report to a board of engineers to be appointed by the two governments.

PUBLICATIONS

The results of stream measurement work in Ontario for the climatic year ending September 30, 1921, are being published as Water Resources Paper No. 34.

STUART S. SCOVIL,
District Chief Engineer.

DISTRICT OF THE MARITIME PROVINCES

During the fiscal year ending March 31, 1922, the operations of the Dominion Water Power Branch in Nova Scotia, New Brunswick and Prince Edward Island, comprising stream measurement and power investigatory work, were continued under the co-operative agreement of July 1, 1919, between the Department of the Interior and the Governments of the three Maritime Provinces.

ORGANIZATION

The work in general comes under two main divisions, hydrometric and power investigatory. The hydrometric portion consists of securing stream-flow data which is basic and fundamental in all power investigatory work and is of prime importance. The power investigatory work follows a programme leading to a complete comprehensive power survey of the three provinces. All important power rivers are investigated as a whole with regard to available heads, storage, water supply, power available, general characteristics and market.

In addition, special power investigations and studies are made in co-operation with the provincial authorities and municipalities, and generally the sequence of investigatory work keeps pace with or anticipates as much as possible the trend of public enquiry towards particular rivers and sites.

CO-OPERATION

The whole work of the Dominion Water Power Branch in the Maritime Provinces is carried on in close co-operation with the Provincial Governments. Wherever possible, investigations and stream measurements are made at the request of the local officials, who in some cases supply assistants to field parties, in order that more detailed surveys may be secured than the branch could otherwise undertake. Such co-operation with the New Brunswick Electric Power Commission permitted the detailed investigation of the Nipisiguit river, which was commenced in September. The Nova Scotia Power Commission was also co-operated with and assisted in their Bear River investigations and in the construction of their Mushamush plant.

In several cases investigations have been made at the request of muncipalities, and practical and economic feasibility of various proposed developments analysed and reported on.

HYDROMETRIC SURVEY

Most abnormal run-off conditions were experienced during the year. The precipitation was greatly below the average and over a large part of the district was the lowest in over fifty years. The stream-flow records obtained under these abnormal drought conditions are of great value in run-off and power studies.

The hydrometric stations maintained are tabulated hereunder:—

REGULAR GAUGING STATIONS

No.	Stream	Location
1AD$_1$	Madawaska	St. Rose.
1AH$_1$	Tobique	Arthurette.
1AK$_1$	Shogomoc	Allandale.
1AK$_2$	St. John	Pokiok.
1AP$_1$	Kennebecasis	Norton.
1AQ$_1$	Lepreaux	Lepreaux.
1AQ$_2$	Magaguadavic	Lee Settlement.
1AQ$_3$	Musquash, west branch	Musquash.
1BE$_1$	Upsalquitch	Upsalquitch.
1BO$_1$	Miramichi	Blackville.
1CA$_1$	Mill	Howlan.
1CA$_2$	Trout	Tyne Valley.
1CB$_1$	Dunk	Roger's mills.
1CC$_1$	Hunter	Hunter River station.
1CD$_1$	Morell	Morell station.
1CE$_1$	Vernon	Vernon River station.
1CE$_2$	Montague	Montague Elec. Lt. Plant.
1DB$_2$	Bear River, east branch	Bear River.
1DC$_3$	Paradise	Paradise.
1DG$_1$	Stewiacke	Upper Stewiacke.
1DG$_2$	Fall	Fall River.
1DG$_3$	Rawdon	Kinsac.
1DH$_1$	Salmon	Valley.
1DJ$_1$	Great Village	Great Village.
1DN$_2$	Phillip	River Phillip P.O.
1DR$_1$	South	St. Andrews.
1EA$_1$	Tusket	West Gavelton.
1EA$_2$	Tusket, west branch	Reynard's bridge.
1EE$_1$	Medway	Charleston.
1EE$_2$	Medway	Harmony mills.
1EF$_1$	LaHave	Bruhm's bridge.
1EH$_2$	Indian	St. Margaret Bay.
1EK$_1$	Musquodoboit	Crawford's falls.
1EM$_1$	East River, Sheet Harbour	Malay falls.
1EO$_1$	St. Mary	Stillwater.
1EO$_2$	Archibald Brook	Stillwater.
1FB$_1$	Margaree, N.E. branch	Frizzleton.
1FB$_3$	Margaree	Upper Margaree.
1FH$_1$	Grand	Loch Lomond.

POWER SURVEYS AND INVESTIGATIONS

The following small streams were investigated at the request of municipalities and others who were considering hydro-electric development on a small scale, to supply their light and power:—

Name of River	For Whom Investigated
Waugh river, N.S	Town of Tatamagouche.
Mulgrave brook, N.S	Town of Mulgrave.
Gibraltar Lakes stream, N.S	Village of Musquodoboit Harbour.
Little river, N.S	Village of Musquodoboit Harbour.
Souris river, P.E.I	Town of Souris.
Maligeak Lake outlets, N.S	Maligeak Lake mines.
Upsalquitch river, N.B	Town of Campbellton.
Caraquette river, N.B	N.B. Electric Power Commission.
Tracadie river, N.B	N.B. Electric Power Commission.
Little Tracadie river, N.B	N.B. Electric Power Commission.
Green river, N.B	Town of Edmundston.
Gaspereau river, N.B	Town of Port Elgin.

The work in general consisted of traverse profiles, cross-sections at dam-sites, investigation of storage and information as to geology, topography, vegetation, market, foundation conditions at proposed structures and such items as would affect cost of construction. Based on this information, estimates would then be prepared covering available power, cost of construction, transmission and distribution, annual costs, market and probable income; and the municipality concerned advised as to the general feasibility of the scheme. If feasible, the retention of a private engineer is recommended, as it is not the purpose to invade the field of private engineering.

In addition to the above preliminary studies, detailed investigations were made at Bear River, in co-operation with the Nova Scotia Power Commission. Contour surveys were made of the storage basins, the proposed regulating reservoir and the site of the head dam. A high level canal route about three miles in length, was also run and contoured, and all possibilities for diversion from neighbouring watersheds thoroughly examined and surveyed.

In New Brunswick, the Nepisiguit survey comprised about 25 miles of river profile and a contour survey covering 7 miles of river, to a height of 100 feet. This survey which is being carried on in co-operation with the New Brunswick Electric Power Commission, is not yet complete. It will be continued during 1922.

During the present fiscal year complete re-writes have been prepared covering all the investigated power streams in the Maritime Provinces, thus bringing into one synopsis all the available data for each stream investigated.

Such results of the power investigatory work as permit of tabulation and which have been computed to date, are given in the following summarized tables:

STORAGE INVESTIGATIONS

Site	Depth of Storage	Capacity in Acre-feet	Remarks
Bear river—			
Lake Mulgrave	20	48,000	
Lake LeMarchant	2	1,000	
Lake Franklin	7	4,200	
Lake Jolly	5	2,800	
Nepisiguit river—			
Above Nepisiguit narrows	100	26,000	11,600 acre-feet at 70-foot depth.

POWER INVESTIGATIONS

Site	Index No.	Head	Flow			Power		
			Ord. Min.	Est. for Max. dev.	Depend. with stor.	Ord. Min.	Est. for Max. dev.	Depend. with stor.
Bear river	1DB1	290	17	100	135	450	2,640	3,560
Waugh river	1DO1	50	12	37	....	55	168	....
Gibraltar river	1EK3	115	1	5	15	10	50	150
Little river	1EK6	19	2	20	14	3	35	24
Souris river	1CE1	30	7	15	....	19	41	....
Maligeak outlet	1EE8	15·4	36	268	250	50	376	350
Gaspereau, N.B.	1BT1	11·5	8	45	45	8	47	47
Green river	1AF1	35	112	314	130	356	999	414
Upsalquitch river	1BE1	40	217	613	....	789	2,210	....
Sheet Harbour river	1EM1	76·5	54	273	324	376	1,900	2,250
	1EM2	112·5	60	292	324	614	2,990	3,320
Nepisiguit	1BK3	70	320	670	....	2,040	4,260	....

CONSTRUCTION

The two largest hydro-electric plants under construction during the year are the St. Margaret Bay plant of the Nova Scotia Power Commission and the Musquash plant of the New Brunswick Electric Power Commission. The St. Margaret Bay plant is about complete in its initial stage of 11,000-horsepower capacity. There remains to be done some four miles of transmission line at the Halifax end and the completion of the Indian Lake and Five Mile storage dams.

The Musquash plant, which is of about the same capacity as the St. Margaret Bay, is well advanced. The main dams, pipelines, surge-tanks, power-house building and transmission line to St. John are about complete. The installation of the hydraulic and electric machinery is under way at the present time. The transmission line is being continued from St. John to Moncton, a further distance of about 90 miles.

A small plant of about 800-horsepower capacity on the Mushamush river was completed in September by the Nova Scotia Power Commission, to supply Lunenburg and Riverport and other small towns in the vicinity.

The Bear River and East River Sheet Harbour projects are being discussed in Nova Scotia but it does not appear at this writing that active construction work can be commenced during 1922. In New Brunswick, the Tetagouche, Lepreaux and Shogomoc developments are projected but it is unlikely that they will be started this year.

PUBLICATIONS

Water Resources Paper No. 29, giving the run-off data for the Maritime Provinces for the years ending September 30, 1919 and 1920, became available for distribution during 1921. The manuscript for it, however, had been completed in 1920. The 1921 material for the next Water Resources Paper is practically in shape for publication.

K. H. SMITH,
District Chief Engineer.

CLASSIFIED LIST OF REPORTS

The Reports published by the Dominion Water Power Branch, with the exception of the Annual Reports, have been called Water Resources Papers, and have been numbered 1, 2, etc.

Annual Reports previous to 1913 are included with the Annual Report of the Department of the Interior, and can be secured from the Secretary of the Department.

Annual Reports for the fiscal years ending March 31, from 1913 to 1922, are available for distribution.

REPORTS OF SPECIAL OR GENERAL INTEREST

Water Resources Paper No. 2.—Report on Bow River Power and Storage Investigations (Bow river west of Calgary), by M. C. Hendry, Chief Engineer in charge of surveys This is a complete study of the Bow river west of Calgary. It deals with meteorological conditions and their effect on run-off and ice formations. Existing and possible power and storage developments, together with maps and plans are appended complete. Published 1914.

Water Resources Paper No. 3.—Report on Power and Storage Investigations, Winnipeg River, by J. T. Johnston, Chief Hydraulic Engineer, Dominion Water Power Branch. A complete study based on field surveys and office computation of the Winnipeg River basin; deals fully with history, international considerations, topography, climate, storage possibilities; describes existing and gives preliminary designs and estimates for possible power developments; discusses other sources of power and the power market. Maps, plans and all relevant data are appended. Published 1915.

Water Resources Paper No. 5.—Preliminary Report on the Pasquia Reclamation Project, by T. H. Dunn, Chief Engineer in charge of Reclamation Survey. This is a progress report of investigation carried out to determine the possibility of lowering the level of Cedar lake and its effect in a general scheme for reclaiming the low-lying lands contiguous to the Saskatchewan river in the Pasquia region. Published 1914. Out of print.

Water Resources Paper No. 6.—Report on cost of various sources of power for pumping in connection with the South Saskatchewan Water Supply Diversion Project, by H. E. M. Kensit. It deals with the problem of power for pumping water from the South Saskatchewan river for the supply of cities and towns in the central portion of South Saskatchewan. Published 1914. Out of print.

Water Resources Paper No. 7.—Report on the Manitoba Water Powers, by D. L. McLean, S. S. Scovil, and J. T. Johnston, compiled for the Manitoba Public Utilities Commission. A general survey of the water-power situation in Manitoba, with all available general information and hydrometric data published to date in condensed form concerning the rivers in Manitoba. Published 1914.

Water Resources Paper No. 10.—General Guide for Compilation of Water Power Reports of Dominion Water Power Branch, prepared for the guidance of field engineers of the Dominion Water Power Branch, by J. T. Johnston, Chief Hydraulic Engineer. Published 1915. Limited edition.

Water Resources Paper No. 11.—Second Report on the Pasquia Reclamation Project by T. H. Dunn, Chief Engineer in charge of Reclamation Survey. This is a continuation report based on further investigations as outlined under Water Resources Paper No. 5. Published 1915. Out of print.

Water Resources Paper No. 12.—Report on Small Water Powers in Western Canada, and discussion of sources of power for the Farm, by A. M. Beale. Part I is a brief description of certain small western water-power developments. Part II gives an analysis of requirements and cost data for the farm power supply. Published 1915. Out of print.

Water Resources Paper No. 13.—Report on the Coquitlam-Buntzen Hydro-Electric Development. A complete description of the project and of the details of construction, with plans, diagrams, and illustrations, by G. R. G. Conway, Chief Engineer of the British Columbia Electric Railway Company, Limited. Published 1915.

Water Resources Paper No. 16.—Water Powers of Canada. A series of five pamphlets in one volume covering the water-power situation in Canada, prepared for distribution at the Panama Pacific Exposition, San Francisco, 1915, by G. R. G. Conway, Consulting Engineer, Toronto; Percival H. Mitchell, Consulting Engineer, Toronto; H. G. Acres, Hydraulic Engineer, Hydro-Electric Power Commission, Ontario; F. T. Kaelin, Asst. Chief Engineer, Shawinigan Water and Power Co., Montreal; K. H. Smith, Engineer, Nova Scotia Water Power Commission, Halifax, N.S. Published 1916.

Water Resources Paper No. 17.—Canadian Hydraulic Power Development and Electric Power in Canadian Industry, by Charles H. Mitchell, Consulting Engineer to Dominion Water Power Branch. Part I deals with progress of utilization, features in design, construction and operation specially applicable to Canada. Description of certain typical Canadian water-power developments. Part II analyzes the uses, growth, and future of electrical power in Canadian Industry. Published 1916.

Water Resources Paper No. 20.—Report on the Interests Dependent on Winnipeg River Power, with Special Reference to the Capital Invested and the Labour Employed, by H. E. M. Kensit. A detailed study of the industrial growth and future power requirements of the district tributary to the Winnipeg River power sites. Published 1917. Out of print.

Water Resources Paper No. 27.—Directory of Central Electric Stations in Canada to January 1, 1919, compiled by J. T. Johnston, Assistant Director, Dominion Water Power Branch. Comprises an analysis of the central electric census statistics and a directory of the stations. Published 1919. Out of print.

Water Resources Paper No. 32.—Water Resources Index Inventory by J. T. Johnston. Description of the Index Inventory System for recording and collating the water resources data of the Dominion. Published 1922.

Water Resources Paper No. 33.—Directory of Central Electric Stations in Canada to November 1, 1922. Comprises an analyzis of the central electric station statistics and a directory of the stations. In course of preparation.

SURFACE WATER SUPPLY REPORTS

ATLANTIC DRAINAGE SOUTH OF ST. LAWRENCE RIVER, INCLUDING NOVA SCOTIA, NEW BRUNSWICK, PRINCE EDWARD ISLAND, AND SOUTHEASTERN QUEBEC

Water Resources Papers Nos. 29 and 37.—Surface water supply of Canada. Reports of hydrometric surveys covering the Atlantic drainage south of the St. Lawrence river including Nova Scotia, New Brunswick, Prince Edward Island and southeastern Quebec, for the climatic years ending September 30, 1919 and 1920, and 1921 and 1922, by K. H. Smith, District Chief Engineer. No. 37 is not yet published.

ST. LAWRENCE AND SOUTHERN HUDSON BAY DRAINAGE IN ONTARIO

Water Resources Papers Nos. 28, 34, and 38.—Surface water supply of Canada. Reports of hydrometric surveys covering the St. Lawrence and southern Hudson Bay drainage in Ontario for the climatic years ending September 30, 1920, 1921 and 1922, by S. S. Scovil, District Chief Engineer. No. 38 is not yet published.

ARCTIC AND WESTERN HUDSON BAY DRAINAGE (AND MISSISSIPPI DRAINAGE IN CANADA) IN ALBERTA, SASKATCHEWAN, MANITOBA, EXTREME WESTERN ONTARIO, AND NORTHWEST TERRITORIES

Water Resources Papers Nos. 4, 19, 22, 24, and 26.—Surface water supply of Canada. Reports of hydrometric surveys in Manitoba, from January 1, 1912, to September 30, 1919, by M. C. Hendry and C. H. Attwood, Chief Engineers. No. 4 contains a gazetteer of lakes and streams in Manitoba.

Water Resources Papers Nos. 31, 36, and 40.—Surface water supply of Canada. Reports of hydrometric surveys covering the Arctic and Western Hudson Bay drainage (and Mississippi drainage in Canada) in Alberta, Saskatchewan, Manitoba, extreme Western Ontario and the Northwest Territories, for the climatic years ending September 30, 1920, 1921 and 1922, by C. H. Attwood and A. L. Ford, District Chief Engineers. Previous to 1919-1920 the surveys in Alberta and Saskatchewan were carried on and the results published by the Reclamation Service, Department of the Interior. No. 40 is not yet published.

PACIFIC DRAINAGE IN BRITISH COLUMBIA AND THE YUKON TERRITORY

Water Resources Papers Nos. 1, 8, 14, 19, 21, 23, 25, 30, 35, and 39.—Surface water supply of Canada. Reports of hydrometric surveys covering the Pacific drainage in British Columbia and the Yukon Territory from May, 1911, to September 30, 1922. No. 1 is by P. A. Carson, Chief Engineer, the others by R. G. Swan, District Chief Engineer. No. 1 contains an outline of the history of the Railway Belt with special reference to its administrative, legal and physical problems in regard to water, and a gazetter of the lakes and streams in British Columbia. No. 39 is not yet published.

Water Resources Papers as listed at the end of this report
are issued free of charge on application to the
Director of Water Power, Department
of the Interior, Ottawa

DEPARTMENT OF THE INTERIOR, CANADA

HON. CHARLES STEWART, Minister; W. W. CORY, C.M.G., Deputy Minister

DOMINION WATER POWER BRANCH

J. B. CHALLIES, C.E., Director

ANNUAL REPORT

1922-23

OTTAWA
F. A. ACLAND
PRINTER TO THE KING'S MOST EXCELLENT MAJESTY
1924

DEPARTMENT OF THE INTERIOR, CANADA
Hon. CHARLES STEWART, Minister; W. W. CORY, C.M.G., Deputy Minister

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ANNUAL REPORT

OF THE

DOMINION WATER POWER BRANCH

PART 1

SCOPE OF ACTIVITIES

PART I

SCOPE OF ACTIVITIES

The past fiscal year saw the Dominion Hydrometric Survey finally rounded out as a Dominion wide organization by the completion of the co-operative agreement with the province of Quebec whereby the organization of the Federal Hydrometric Survey was extended to that province.

The past year was also noteworthy as producing a decided acceleration of water-power development; Canada appears to have nearly accomplished the transition from war to peace conditions; industry is stabilizing, and capital is available for development in quantities and for rates unobtainable since 1914. New water-power enterprises have been initiated at many widely separated points and these combined with the increasing cost of coal justify the expectation that water-power installation in Canada will continue to grow at a rate at least as great as that maintained during the past decade.

Organization

The activities of the Dominion Water Power Branch are both administrative and investigatory. The administrative phase of the work arises from the proprietary interest of the Dominion in the water resources in the provinces of Alberta, Saskatchewan and Manitoba, the Northwest and Yukon Territories, and in the Railway Belt of British Columbia. In this connection the department must of necessity secure such fundamental engineering and economic data as will enable it to consider applications for power privileges, and to control the development, the distribution and the sale of hydro-electric energy. This is the prime responsibility of the branch.

Throughout the remainder of the Dominion the water-powers are vested in the provinces and investigatory work is carried on in co-operation with the respective provincial authorities charged with their administration. The branch also co-operates extensively with federal departments and commissions other than the Department of the Interior, the services of its engineering field staff, in the interests of general economy and efficiency, being made available to such other departments and commissions.

The co-operative facilities for water resources investigation work throughout the Dominion are as follows:—

British Columbia.—The local organization of the branch, with headquarters at 119 Pender street west, Vancouver, carries on a broadly planned hydrometric survey and systematically secures fundamental data necessary to a complete analysis of the water-power resources, in accordance with the terms of a co-operative agreement with the Provincial Water Rights Branch of British Columbia.

Alberta and Saskatchewan.—The local organization of the branch, with headquarters at 513 Eighth avenue west, Calgary, carries on direct administrative work throughout all parts of the two provinces, in virtue of the proprietary interest of the department in their water-power resources. The investigatory work comprises a comprehensive hydrometric survey and a systematic and exhaustive field and office analysis of the water-power resources of the two provinces.

Manitoba.—The local organization of the branch, with headquarters at 231 Chambers of Commerce Block, Winnipeg, carries on direct administrative work throughout the province, in virtue of the proprietary interest of the department in the provincial water-power resources. A comprehensive hydrometric survey is maintained, as well as a systematic and exhaustive field and office analysis of the provincial water-power resources. In the interests of administrative economy the investigatory work carried on through the Manitoba office has been extended to cover that portion of Ontario lying west of and including lake Nipigon.

Ontario.—The local organization of the branch, with headquarters at Ottawa, carries on a comprehensive hydrometric survey and systematically secures fundamental water resources data in accordance with the terms of a co-operative agreement with the Ontario authorities. The closest co-operation is maintained with the staff of the Ontario Hydro-Electric Power Commission.

Quebec.—The local organization of the branch, recently established with headquarters at Postal Station "H," corner of St. Catherine and Bishop streets, Montreal, is developing a comprehensive hydrometric survey and has commenced the systematic collection of fundamental water resources data as required by the terms of the co-operative agreement with the Quebec authorities. The closest co-operation is being maintained with the staff of the Quebec Streams Commission.

The Maritime Provinces.—The local organization of the branch with headquarters at 193 Hollis street, Halifax, in accordance with the terms of a co-operative agreement with the three respective provincial authorities of New Brunswick, Nova Scotia and Prince Edward Island, carries on a systematic hydrometric survey and a comprehensive and continuous power and storage survey of the three provinces, with a view to securing the fundamental data necessary to a complete analysis of their water-power resources. In New Brunswick, the branch collaborates with the New Brunswick Electric Power Commission; in Nova Scotia with the Nova Scotia Power Commission; and in Prince Edward Island with the provincial authorities.

Yukon and Northwest Territories.—Administrative and investigatory work in the Territories form a direct responsibility of the Dominion Water Power Branch in virtue of the proprietary interest of the department in their water-power resources. Investigatory work in the Yukon is handled through the British Columbia organization. In the remainder of the Territories such work is directed from head office, as exigencies demand.

The field organization of the department is based upon and built up around the Dominion Hydrometric Survey staff, through which systematic and continuous stream measurement studies are carried on throughout the Dominion. The hydrometric survey field staff are employed in a systematic and continuous field analysis of the country's water-power resources. The data systematically accumulated through this work and through co-operative agreements and studies with other organizations is collated, analysed and standardized in the head office of the branch at Ottawa.

As a result, there is now on file in the offices of the Dominion Water Power Branch general and detailed information in respect to run-off and power possibilities of the more important power rivers throughout the Dominion. These

data are constantly being brought up to date as new or later information is received and is promptly available for reference purposes to all interested in the utilization of the water-powers of the Dominion.

The Lake of the Woods Control Board

The Lake of the Woods Control Board was as in the previous year, responsible for the regulation of the level and outflow of lake of the Woods. At the same time certain investigations were carried on in connection with the storage potentialities of lac Seul and of the boundary waters tributary to Rainy lake.

As heretofore regulation of lake of the Woods embraced the continuous collection of hydrological data relating to the watershed. High precipitation immediately previous to and during spring breakup necessitated the full opening of the Norman dam in April. As a consequence of this precautionary measure lake level did not exceed an elevation of 1,060·6 feet, a stage reached on May 25. High outflow was maintained until the first week in July when a partial closure of the Norman dam was ordered. Lack of precipitation in September required the complete closure of the Norman dam but as a result of continued drought in the following month lake level dropped to an elevation of 1,059·1 feet. High precipitation occurred at the time of freeze-up and there was a consequent rise in lake level throughout the winter months.

In conformity with the recommendation of the International Joint Commission for the providing of increased outflow capacity from lake of the Woods, the board carried on detailed field and office investigations of the most feasible and proper method of providing such increased capacity.

Necessary to a final recommendation by the board as to the storage range on lac Seul, continuous records of lake level and outflow were secured throughout the year. At the same time interrelated investigations were made of the upper English river and at the request of the board, the Geodetic Survey of Canada traced a line of precise levels from lac Seul to the junction of the Winnipeg and English rivers and from the latter point up the Winnipeg river to Kenora.

Water-power Regulations and Legal Research

The collection of translations of foreign acts and regulations has been continued during the year.

There has been considerable activity in water-power development in Europe, and this has necessitated some modifications in the basic laws passed by most of the European countries in the period 1916 to 1920, to which reference was made in the Annual Report of the Dominion Water Power Branch for 1921-22, in order to provide for changing economic and industrial conditions. This has been particularly the case in France and Italy, where economic conditions have been somewhat difficult, and has caused a series of changes to be made in the general regulations for the acquisition and development of water-powers adopted by these countries in 1919 and 1920. These supplementary decrees have been translated, and the records containing the water-power laws of Norway, Switzerland, France, and Italy have been revised in accordance with the new material received.

Official publications dealing with the national electrical systems of Germany and Sweden, the electrification of the Swedish state railways, and the administrative systems of Switzerland and the Dutch East Indies were also received and translated.

The revised Dominion Water Power Regulations which have been in force since October 31, 1921, were described at some length in the Annual Report for 1921-22 so that no further reference to their provisions need be made at this time. As they are somewhat long and perhaps difficult to grasp without

considerable study, an explanatory pamphlet has been prepared which describes briefly the principles on which they are based, outlines the various steps to be taken in acquiring a license under the Water Power Act, and explains the general rights and obligations of a licensee with particular reference to the financial conditions affecting the security of his investment, such as the initial financing of the undertaking, rentals payable to the Crown, regulation of rates, service and the issue of securities, the compensation payable to the licensee when the license is terminated or cancelled, and the conditions under which a license may be so terminated or cancelled.

Copies of this pamphlet and of the regulations themselves may be obtained on application to the Director of Water Power.

During the year a systematic study was begun of the laws passed by the various legislative bodies in Canada since their inception dealing with the uses of water, with particular reference to the development of power. This survey of the legal principles and administrative procedure which form the basis of water-power development throughout Canada is substantially completed as regards the provinces of British Columbia, Alberta, Saskatchewan, and Manitoba. and some progress has been made with the Maritime Provinces. It is hoped to complete this work during the coming year, after which it will be published in suitable form. It is believed that this is a subject which has not hitherto received adequate attention and that the published results will be found useful for a variety of purposes.

In connection with this work a list of the acts at present in force in Canada governing the use of water was prepared at the request of the Commissioner of Drainage and Waters of the State of Minnesota.

British Columbia Administration

In the Railway Belt of British Columbia the waters and water-powers, although they form part of the public property of the Dominion, are administered by the provincial authorities (except within the Dominion parks) under the provincial Water Acts, and as the Dominion lands within the Railway Belt are administered by this department, it is necessary that the two systems of administration work together in haromny. This involves close co-operation between the Dominion and provincial officials, which has been attained in a very satisfactory manner, and enables the responsible officers of this department to exercise a proper degree of supervision over Dominion interests in the waters and the other natural resources affected by their use, and at the same time establishes a uniform method of acquiring water rights for all purposes throughout the province.

The examination of water records issued by the province appurtenant to lands within the Railway Belt has been continued and the work further systematized; plans are compiled to show the lands affected in each case, and the granting of necessary rights of use or occupation of Dominion lands under the Water Lands Regulations is proceeding satisfactorily in co-operation with the British Columbia Lands Branch and the Forestry Branch of this department.

A considerable amount of work is done in the Railway Belt by the branch engineers on behalf of the Department of Indian Affairs. Reports are prepared dealing with systems of water supply for the Indian reserves for irrigation, domestic and other purposes, and works of this nature authorized by the Indian department are carried out under the supervision of the branch engineers.

Another important phase of this work is the investigation of water rights appurtenant to the Indian reserves in the province, collecting material in support of the Indian claims and preparng it for the information of the Board of Investigation under the Water Act. Five reports have been prepared in this connection tabulating the water records appurtenant to Indian reserves in each of the five agencies in the Railway Belt, and the information thus compiled has

been of great assistance to the board in their work of adjudication and has enabled the Indian claims to be adequately presented at the hearings held by the board.

Water Resources Index Inventory

The Index Inventory system for recording and collating the water resources data of the Dominion has been in actual use for the past few years and has provided a most efficient method for the referencing, analysis, standardization and filing of all data relating to the subject of water resources. The fundamental principles of this system have been referred to in previous annual reports and a complete description has been published as Water Resources Paper No. 32.

The system has been applied to practically all phases of the work carried on by the branch, among the more outstanding of which may be mentioned the complete census of developed water-power and central electric station activities, the analysis of the undeveloped water-power resources, the analysis of the stream measurement activities and the storage studies carried on throughout the Dominion.

This work has been largely carried on in co-operation with provincial organizations, notably the Hydro-Electric Power Commission of Ontario, the Quebec Streams Commission, the Water Rights Branch of British Columbia, the New Brunswick Electric Power Commission, and the Nova Scotia Power Commission, and resulting therefrom a large proportion of the water resources data of the Dominion has been compiled in standardized form for whatever purpose required. This material is being continually revised and brought up-to-date as authentic information is secured.

Water Power Resources of Canada

The continued growth of hydraulic power installation in this country to the present total plant capacity of 2,973,759 horse-power and the direct dependence of Canadian industry as a whole on hydraulic and hydro-electric enterprise makes it a matter of some importance that existing research into water-power resources be periodically brought to date and made available for public study.

Water-power is in itself one of the country's basic and most valuable natural resources, and the capital invested in its development, well over half a billion dollars, makes it also one of our greatest single industries.

Knowledge of this resource is far from complete and information in many details is conflicting, but at the present time, largely as a result of the work of the Department of the Interior, a great mass of reasonably accurate as well as considerable specific data is now on file for the use of engineers and others interested. Every effort is made to keep this material constantly up to date.

During the past three years all existing stream flow and power data available from federal, provincial and private sources have been systematically collated, re-analysed and co-ordinated, with a view to preparing revised estimates of available power based on uniform methods of computation and arrangement.

BASIS OF COMPUTATION

The figures for undeveloped water-power listed in table 1 are based upon rapids, falls and power sites of which the actual existent drop or the head possible of concentration, is definitely established or at least well authenticated. Many rapids and falls of greater or lesser power capacity are scattered on rivers and streams from coast to coast which are not as yet recorded, and which will only become available for tabulation as more detailed survey work is

undertaken and completed. This is particularly true in the relatively unexplored northern districts. Nor is any consideration given to the power concentrations which are feasible on rivers and streams of gradual gradient, where economic heads may be created by the construction of power-dams, excepting only at such points as definite studies have been carried out and the results made matters of record.

In brief, the figures hereunder are based on definite rapids, falls and power sites, and may be said to represent the *minimum water-power possibilities* of the Dominion.

The power estimates have been calculated on the basis of 24-hour power at 80 per cent efficiency for conditions of "Ordinary Minimum Flow" and "Estimated Flow for Maximum Development." The "Ordinary Minimum Flow" is based on the averages of the minimum flow for the lowest two consecutive seven-day periods in each year, over the period for which records are available. The "Estimated Flow for Maximum Development" is based upon the continuous power indicated by the flow of the stream for six months in the year. The actual method to determine this flow is to arrange the months of each year according to the day of the lowest flow in each. The lowest of the six high months is taken as the basic month. The average flow of the lowest seven consecutive days in this month determines the maximum for that year. The average of such maximum figures for all years in the period for which data are available is the estimated maximum used in the calculation.

This estimated maximum development is based upon the assumption that it is good commercial practice to develop wheel installation up to an amount, the continued operation of which can be assured during six months of the year, on the assumption that the deficiency in power during the remainder of the year can be profitably provided from storage or by the installation of fuel-power plants as auxiliaries. The correctness or otherwise of this assumption for any particular site can only be definitely settled by careful consideration of all circumstances and conditions pertinent to its development. The method, however, enables us to make a fairly satisfactory over-all estimate of the maximum hydraulic power available as distinctive from the estimated ordinary minimum power available.

AVAILABLE AND DEVELOPED TOTALS

The known available water-power in Canada, from all sources and within the limitations outlined, is 18,255,000 horse-power for conditions of ordinary minimum flow and 32,076,000 horse-power under a flow estimated for maximum development, i.e., dependable for at least six months of the year.

It is believed that these are conservative estimates since an analysis of th water-power plants scattered from coast to coast concerning which complete data are available as to turbine installation and satisfactory information as to stream flow, gives an average machine installation 30 per cent greater than the six-month flow maximum power. Applying this, the figures quoted above therefore indicate that the *present recorded water-power resources* of the Dominion will permit of a turbine installation of 41,700,000 horse-power.

The total installation to date in water-wheels and turbines through the Dominion is 2,973,759 horse-power. In other words the present turbine installation represents only *7 per cent* of the recorded water-power resources.

CURRENT PROGRESS

The sustained, and in many cases increased earning power of existing hydro-electric organizations, both privately and publicly owned, during the past few years of deflation following the war stimulus has been reflected in the encouraging treatment of the securities of these concerns on the various financial exchanges, and has created a favourable impression on capital, and generally

established a public confidence that is proving of value in the further promotion and growth of hydro-electric enterprises.

The period of high and uncertain construction costs resulting from war time conditions is definitely passing. Works which a few years ago would not be undertaken by contractors except on a cost-plus basis can now be met by simple inclusive tender. Labour conditions are slowly stabilizing. The power industry has established its capacity to manufacture cheaply and market its wares profitably under trying and exacting circumstances. There seems little to impede and much to encourage increased development.

It is not surprising therefore that many large developments are under way and many others under consideration, so that a continuation of the steady progress of new installation during the last two years, may be looked forward to with confidence.

The progress of development is somewhat difficult to follow from year to year because the year is too short an interval. From three to five years or even longer often elapses between the first consideration of development and the delivery of power. Again most projects commence with an initial installation much less than the ultimate projected capacity and new units of machinery are installed from time to time as the load develops. In other words what may be called the scoring column often does not reflect new construction for some years after such construction has been actively under way, but continues to record new scores from old developments.

UTILIZATION OF DEVELOPED WATER-POWER

The 2,973,759 horse-power at present installed in this country may be classified as follows (see table 2):—

- 2,204,486 horse-power in central stations for general distribution for all purposes.
- 484,228 horse-power installed in pulp and paper mills, not including 160,577 horse-power purchased by pulp and paper companies from central stations.
- 285,045 horse-power installed in industries other than central stations and pulp and paper mills.

The total installation for the Dominion averages 338 horse-power per thousand population, a figure which maintains Canada's position as second only to Norway in the per capita utilization of water-power among the countries of the world.

WATER-POWER IN THE CENTRAL STATION INDUSTRY

Modern developments in high-tension electrical transmission, which permit the economic transportation of power at small loss over relatively long distances has made possible the use of hydraulic power for manufacturing in established centres where labour is plentiful and of a permanent character, with shipping and distributing facilities readily at hand. Such centres, with their variety of manufacturing needs and processes, street railways to be operated, buildings to be lighted and heated, municipal needs for street lighting and water pumping, form an ideal market for the product of the central electric station and have resulted in the central station industry attaining enormous proportions in a relatively short period of time.

Throughout the Dominion there were, at February 1, 1923, 273 hydro-electric central stations with an installed turbine capacity of 2,204,486 horse-power, or a generator installation of 1,636,084 kv. a. (see table No. 3), of which totals 1,556,956 horse-power were installed in commercial or privately owned stations while 647,530 horse-power were installed in municipal or publicly owned stations.

The units vary in size from 10-horsepower to the 55,000-horsepower turbines recently installed in the Queenston development of the Ontario Hydro-Electric Power Commission, and which are the largest operating water-turbines in existence at the time of writing. The turbine units in the industry average 3,483 horse-power, while the average installation of the central stations is 8,075 horse-power.

Unremitting progress in operating efficiency and wider fields of service are being constantly maintained by the operating companies and interested government departments. New units are being installed, new plants constructed, new projects investigated and research instigated to meet the growing domestic and industrial demand and to link up the hitherto isolated small centres and rural districts with cheap hydro-electric power.

WATER-POWER IN THE PULP AND PAPER INDUSTRY

Pulp and paper manufacturing is a typical and pre-eminent Canadian industry with a future of great potentialities, the result of two natural advantages of almost equal moment, namely, an abundant supply of growing pulpwood and cheap accessible motive power in large quantities. The importance of cheap power lies in the fact that it takes practically 100 horse-power to produce one ton of paper per day. It is not surprising therefore that motive power used in this industry is almost altogether restricted to hydraulic energy and that Canada's premier advantage and position in the pulp and paper field rests on adequate and abundant water-power well distributed among extensive forest reserves.

Water-power is operating 113 pulp and paper mills in Canada, 644,805 horse-power being employed. Of this total, 484,228 horse-power is *actually installed* in connection with the mills and 160,577 horse-power is *purchased* from hydro-electric central stations.

The innovation of the electric drive is having a marked and favourable influence on pulp and paper manufacturing processes. It makes possible the centralized operation of fewer and larger mills receiving power from several power sites together with the further advantage of uniform speed and better control in grinding, thus lessening costs of operation, construction and shipping. Of the 484,228 horse-power *actually installed* in pulp and paper mills 183,311 horse-power is used in the electric drive, besides which there is 160,577 horse-power of hydro-electric energy purchased from central stations, bringing the total horse-power employed in the electric drive up to 343,888 horse-power.

Quebec and Ontario possess the largest natural pulpwood areas in Canada and they lead in pulp and paper production with 320,192 horse-power utilized in this industry in Quebec and 243,146 horse-power in Ontario; other producing provinces are British Columbia, 48,800 horse-power; New Brunswick, 14,668 horse-power; and Nova Scotia, 17,900 horse-power; total installation for pulp and paper mills, 644,805 horse-power.

PAST AND FUTURE GROWTH IN UTILIZATION OF WATER-POWER

The growth of water-power developments in Canada has been striking. Total installed horse-power has grown from 975,000 to 2,974,000 since 1910; central station installation from 605,000 to 2,204,000 horse-power, and pulp and paper installation from 191,000 to 484,000 horse-power.

There is every reason to believe that this rate of growth will not diminish. New uses for electric current of the greatest import in industrial processes and services are being constantly discovered. Canada's strategic advantage in the location of large reserves of water-power within transmission distance of her centres of population should attract special industries to these centres in increasing numbers. Population follows industry and at once an added market

is created for power for domestic and municipal uses. All the modern tendencies in the utilization of cheap power indicate that the rate of growth of hydro-electric development in Canada will increase rather than lessen.

Should the rate of installation since 1910 be maintained at its present rate there will be installed in 1925, 3,360,000 horse-power; in 1930, 4,110,000 horse-power; in 1935, 4,800,000 horse-power; and in 1940, 5,600,000 horse-power. These growth figures are considered conservative. Available reserves are more than ample to take care of these future demands, as outlined, for a long time to come.

The water-power now developed in Canada represents an investment of over $620,000,000. In 1940 should the rate of growth in installation during the past fifteen years be continued, this investment will have grown to over $1,100,000,000. The present development represents an annual equivalent of 26,700,000 tons of coal which, valued at $10 per ton, represents $267,000,000. In the year 1940 these annual figures will, with the foregoing assumption, have become 50,000,000 tons and $500,000,000. These figures are striking evidence of the outstanding importance and necessity of an intelligent administrative policy governing the development of our water-power resources.

Table No. 1.—Available and Developed Water-Power in Canada—February 1, 1923

Province	Available 24-hour power at 80 per cent efficiency		Turbine Installation. Horse-power
	At ordinary min. flow. Horse-power	At est. flow for max. dev. (Dependable for 6 months. Horse-power)	
1	2	3	4
British Columbia	1,931,142	5,103,460	328,977
Alberta	475,281	1,137,505	33,067
Saskatchewan	513,481	1,087,756	....
Manitoba	3,270,491	5,769,444	134,025
Ontario	4,950,300	6,808,190	1,299,230
Quebec	6,915,244	11,640,052	1,073,883
New Brunswick	50,406	120,807	42,039
Nova Scotia	20,731	128,264	47,100
Prince Edward Island	3,000	5,270	2,239
Yukon and Northwest Territories	125,220	275,250	13,199
	18,255,316	32,075,998	2,973,759

The figures listed in columns 2 and 3 in the above table represent 24-hour power and are based upon rapids, falls and power sites of which the actual existent drop or the head possible of concentration, is definitely known or at least well established. Many rapids and falls of greater or lesser power capacity are scattered on rivers and streams from coast to coast which are not as yet recorded, and which will only become available for tabulation as more detailed survey work is undertaken and completed. This is particularly true in the relatively unexplored northern districts. Nor is any consideration given to the power concentrations which are feasible on rivers and streams of gradual gradient, where economic heads may be created by the construction of power-dams, excepting only at such points as definite studies have been carried out and the results made matters of record.

The figures in column 4 represent the actual water-wheels installed throughout the Dominion. These figures should not be placed in direct comparison with the available power figures in columns 2 and 3 for the purpose of deducing therefrom the percentage of the available water-power resources developed to date. The actual water-wheel installation throughout the Dominion averages 30 per cent greater than corresponding maximum available power figures calculated as in column 3. The figures quoted above therefore indicate that the *at present recorded water-power resources* of the Dominion will permit of a turbine installation of *41,700,000 horse-power*. In other words, the present turbine installation represents only *7 per cent* of the present recorded water-power resources.

The above figures may be said to represent the *minimum water-power possibilities* of the Dominion. As illustrative of this the detailed analyses which have been made of the water-power resources of the provinces of New Brunswick and Nova Scotia have disclosed most advantageous reservoir facilities for regulating stream flow and it is estimated that the two provinces possess within their respective borders 200,000 and 300,000 commercial horse-power. These figures provide for a diversity factor between installed power and consumers' demands.

Table No. 2.—Developed Water-Power in Canada—February 1, 1923

Province	Turbine Installation in Horse-power				Population Census of June, 1921	Total installation per 1,000 population H.P.
	In Central Stations	In Pulp and Paper Mills	In other Industries	Total		
1	2	3	4	5	6	7
British Columbia	227,401	48,800	52,776	328,977	524,582	627
Alberta	32,380	....	687	33,067	588,454	56
Saskatchewan	....	....	....	....	757,510	....
Manitoba	117,625	....	16,400	134,025	610,118	220
Ontario	1,018,853	171,024	109,353	1,299,230	2,933,662	443
Quebec	761,480	231,737	80,666	1,073,883	2,361,199	445
New Brunswick	21,113	14,668	6,258	42,039	387,876	108
Nova Scotia	15,346	17,999	13,755	47,100	523,837	90
Prince Edward Island	288	....	1,951	2,239	88,615	25
Yukon	10,000	....	3,199	13,199	4,157	3,175
Canada	2,204,486	484,228	285,045	2,973,759	8,788,483	338

Column 2 includes only hydro-electric stations which develop power for sale.

Column 3 includes only water-power *actually developed* by pulp and paper companies. In addition to this total, pulp and paper companies purchase from the hydro-power central stations totalled in column 2, 72,122 horse-power in Ontario and 88,455 horse-power in Quebec. The total hydro-power utilized in the pulp and paper industry is therefore 644,805 horse-power.

Column 4 includes only water-power actually developed in connection with industries other than the central station and the pulp and paper industries. These industries also purchase blocks of power from the central stations totalled in column 2.

Column 5 totals all turbines and water-wheels installed in Canada.

Column 6, total population, includes 7,988 in North West Territories and 485 in the Royal Canadian Navy.

Column 7 averages the developed water-power per 1,000 population.

Table No. 3.—Developed Water-Power in Canada Utilized in the Central Station Industry.—February 1, 1923.

Province	Commercial Stations			Municipal Stations			Total				
		Installation			Installation			Installation			
	No.	Generator Kv. a.	Turbine Horse-power	No.	Generator Kv. a.	Turbine Horse-power	No.	Generator Kv. a.	Horse-power per Turbine Unit	Horse-power per Station	Total Turbine Horse-power
1	2	3	4	5	6	7	8	9	10	11	12
British Columbia	23	141,686	217,356	8	6,353	10,045	31	148,039	3,990	7,335	227,401
Alberta	3	22,250	32,380	......	......	......	3	22,250	2,491	10,793	32,380
Saskatchewan	......	......	......	......	......	......	......	......	......	......	......
Manitoba	3	37,350	50,400	2	57,312	67,225	5	94,662	5,881	23,525	117,625
Ontario	67	387,159	492,025	37	353,362	526,828	104	740,521	3,742	9,796	1,018,853
Quebec	77	582,413	743,855	16	13,202	17,625	93	595,615	3,541	8,188	761,480
New Brunswick	7	6,585	9,203	3	9,363	11,910	10	15,948	960	2,111	21,113
Nova Scotia	8	1,479	1,449	11	11,239	13,897	19	12,718	667	808	15,346
Prince Edward Island	7	331	288	......	......	......	7	331	32	41	288
Yukon	1	6,000	10,000	......	......	......	1	6,000	5,000	10,000	10,000
Canada	196	1,185,253	1,556,956	77	450,831	647,530	273	1,636,084	3,483	8,075	2,204,486

Commercial Stations include all privately owned.
Municipal Stations include all publicly owned.

NOTE.—Statistics in this table are based upon a census of the industry made by the Dominion Bureau of Statistics in co-operation with the Dominion Water Power Branch.

Table No. 4.—Developed Water Power in Canada Utilized in the Pulp and Paper Industry—February 1, 1923.

Province	No. of Mills	Installed and Purchased Power—Horse power					
		Turbine Installation in the Industry			Purchased Hydro-Electric Power	Total Hydro-Electric, col. 4 and col. 6	Total utilized in the Industry, col. 5 and col. 6
		Direct Drive	Hydro-Electric Drive	Total			
1	2	3	4	5	6	7	8
British Columbia	5	27,975	20,825	48,800	....	20,825	48,800
Ontario	41	89,830	81,194	171,024	72,122	153,316	243,146
Quebec	54	162,825	68,912	231,737	88,455	157,367	320,192
New Brunswick	3	2,368	12,300	14,668	....	12,300	14,668
Nova Scotia	10	17,919	80	17,999	....	80	17,999
Canada	113	300,917	183,311	484,228	160,577	343,888	644,805

Column 3 includes all turbines actually installed in the industry and *directly* driving mill equipment.
Column 4 includes all turbines actually installed in the industry and transmitting power through *electric drive.*
Column 5 totals the turbine capacity actually installed in the industry.
Column 6 includes only power purchased from hydro-electric central stations for the operation of pulp and paper mills.
Column 7 totals the hydro-electric power used in the industry.
Column 8 totals the water-power used in the industry.

Hydro-Electric Progress in Canada in 1922

The water-power industry may be likened to a fly-wheel in that it possesses a momentum which enables it to traverse periods of depression and great industrial activity without excessive fluctuations. The history of water-power development in Canada has been one of steady progress and the industry has been a stable one. Whether times have been good or bad the output has been steadily growing, when general business has been poor and interest rates high the increase has been provided for by the gradual expansion of existing developments, whilst as general business conditions improve new enterprises are undertaken.

From figures compiled by the branch it is shown that during 1922 the total water-power installation in Canada grew to approximately 3,000,000 horse-power, of which 240,000 were installed during the year; this figure does not include 190,000 horse-power installed during 1921, but only brought into operation after that year closed.

The most significant feature of 1922 from the hydro-electric standpoint was the initiation of new development. Projects are under way which will have an ultimate capacity of over one million horse-power, thus indicating in no uncertain manner that the progress maintained through the war and post-war periods largely by the extension of existing developments will be sustained and probably stimulated by entirely new enterprise.

The details of progress during 1922 are set forth in the following paragraphs, but special attention may be called to the storage developments on Stave lake and Falls creek in British Columbia to increase the output of existing plants; the development of the Manitoba Power Company at Great falls on the Winnipeg river, where the first unit of a 168,000-horsepower development was put into service in December; the rapid increase of installation by the Ontario Hydro-Electric Commission at Queenston; the great activity in Quebec, which includes immense developments under way on the Saguenay river and at Gres

falls on the St. Maurice; also the steadily maintained progress in the Maritime Provinces. The particulars of the progress during 1922 by provinces is as follows:—

BRITISH COLUMBIA

New hydro-electric construction work in British Columbia during 1922 included a development of 7,200 horse-power on the Bull river in the south-eastern corner of the province, by the East Kootenay Power Company. This plant serves an important mining area in the Fernie-Cranbrook district. The same company also commenced construction of a 24,000-horsepower development on the Elk river near Elko. The initial installation, which will consist of two 8,000-horsepower turbines, is expected to be completed by the fall of 1923.

The British Columbia Electric Railway Company has under construction extensive alterations to its development at Stave falls, at the outlet of Stave lake, involving an expenditure of $1,250,000. The main dam is being raised 20 feet and additional side dams are being erected which will approximately double the water storage. An additional unit of 13,000 horse-power was installed and placed in operation in November, 1922, which brings the total in this plant to 52,000 horse-power; provision is also being made for the addition of a fifth unit.

The Granby Consolidated Mining and Smelting Company in 1922 commenced construction of a large concrete storage dam on Falls creek, near Anyox, at an estimated cost of $500,000. When complete this dam will provide additional storage of 25,000 acre-feet which is intended to eliminate the necessity for steam generated power for the company's plant and smelter. The company contemplates the installation of a new 3,600-kilowatt unit during 1923.

The Pacific Mills Limited, at Ocean falls, also commenced in 1922 the work of raising their existing dam an additional 15 feet to provide additional storage of water.

Towards the close of the year activity was being evinced in a project to develop power on the Adams river for the supply of Kamloops and adjacent territory. Ratepayers of Kamloops have since passed a by-law authorizing a contract being made for a block of power from this development if it is proceeded with.

MANITOBA

At Great falls, on the Winnipeg river in Manitoba, the first milestone in the completion of the 168,000-horsepower development of the Manitoba Power Company was passed on December 28, 1922, when the first unit of 28,000 horse-power was placed in operation under partial head. This event was the culmination of a year of remarkable constructional achievement in which the programme, as planned by the company, was carried out in every respect. The initial installation in this plant will consist of two units totalling 56,000 horse-power and provision has been made for four additional units of 28,000 horse-power each, giving an ultimate capacity of 168,000 horse-power.

The municipal plant of the city of Winnipeg at Pointe du Bois, on the Winnipeg river, was increased in capacity during 1922 by the addition of a unit of 6,900 horse-power. This brings the installation in this plant to eleven units, aggregating 67,100 horse-power. Provision still remains for the addition of five more units which will be added as the growth of the load demands.

In preparation for still further demands for power the city commenced studies of a development at Slave falls, five miles below Pointe du Bois on the Winnipeg river. It is also of interest to record that the city has decided to construct a steam stand-by plant in Winnipeg of 15,000-horsepower capacity to be operated in the event of temporary breakdowns in the hydro-electric supply.

ONTARIO

As in recent years the construction operations of the Ontario Hydro-Electric Power Commission during 1922 ranked first in magnitude. Work continued throughout the year on the 550,000-horsepower Queenston-Chippawa development and the initial stage of this project now nears completion. Of the five 55,000-horsepower units included in this initial installation the first was placed in operation in December, 1921, the second, third and fourth in 1922 and the fifth is expected to be ready early in the present year. Due to the rapid increase in the load on the Niagara system, plans are being advanced for the completion of the Queenston station to the full 550,000 horse-power.

At Ranney falls on the Trent river near Campbellford, Ont., the new 10,000-horsepower development of the commission was completed and placed in operation during August last. Additional powers on the Trent river at dams 8 and 9 are now being investigated by the commission, also powers at Bingham chute on the South river and at Port Severn on the Severn river.

The Canadian General Electric Company completed the reconstruction of their development at Nassau on the Otonabee river by the addition of a 1,300-horsepower unit. The power is used in the company's works at Peterborough.

In northern Ontario two new developments to serve the gold and silver mining areas were placed under construction and the work well advanced before the end of the year. At Sturgeon falls, on the Mattagami river, the Lower Sturgeon Power Company, Limited, are installing 8,000 horse-power to serve the mines at Porcupine and expect to have the power available in February or March of the present year. At Indian chute, on the Montreal river, the Great Northern Power Company, Limited, are constructing a development with a designed capacity of 6,450 horse-power. It is expected to place the first unit of 2,150 horse-power in operation during March this year. The output from this plant will serve mines in adjacent territory.

At Kapuskasing, on the Kapuskasing river, the Spruce Falls Company have under construction a development with an initial installation of 2,500 horse-power to supply power to their pulp mill at that place. This work was well advanced at the end of 1922.

On the little Thessalon river the town of Thessalon constructed a development of 200 horse-power which went into operation in December last and is serving the town with light and power.

In northwestern Ontario at Kenora the Backus-Brooks Company completed the installation of 4,800 horse-power in the power development at the outlet of the lake of the Woods formerly owned by the town of Kenora. Present plans contemplate the addition of new units during the present year which will bring the total installation to 10,800 horse-power.

In the same district also the Dryden Paper Company commenced construction on a new plant at Wainwright falls on the Wabigoon river, four miles northwest of Dryden. A single unit of 1,400 horse-power is being installed and is expected to be in place in February, 1923.

The total turbine capacity installed in Ontario during 1922 amounted to 130,300 horse-power, with provision well advanced for extensive additions in 1923.

It is of interest to record that during the year a report was presented to the Temiskaming and Northern Ontario Railway Commission by engineers engaged for the purpose, which recommended the electrification of the railway and advised that powers on the Amable-du-Fond, Blanche and Frederickhouse rivers be reserved for the same.

QUEBEC

In the province of Quebec the turbine capacity actually installed during 1922 did not reach the figure of the previous year, but a number of very

important projects were commenced which will add very materially to the utilization of the large power resources of the province. At Shawinigan falls, on the St. Maurice river, a unit of 43,000 horse-power was installed and placed in operation during October in No. 2 power-house of the Shawinigan Water and Power Company. Provision has also been made for the addition of two more such units. At the Grand'Mère plant of the Laurentide Power Company the two 22,000-horsepower units which had been installed in 1921 were placed in operation, and similarly at the Cedars plant on the St. Lawrence river, of the Montreal Light, Heat and Power Consolidated the two 11,300-horsepower units installed in 1921 went into operation. For the latter plant four additional units have been ordered, some of which are expected to be in operation in the autumn of 1923.

Among other hydro-electric developments placed in operation during 1922 may be mentioned a 150-horsepower plant at St. Prime, in the lake St. John district; a 350-horsepower plant at Papineauville, on the Little Nation river, replacing a previous plant destroyed by fire, and a new plant of 400 horse-power on the Blanche river, in Labelle county placed in operation during November by Cie. Electrique de Rockland Ltee. to supply Rockland, Ont., and other municipalities. In this connection may also be mentioned the completion of a new concrete dam by the Pembroke Electric Company at their 4,000-horsepower plant on the Black river at Waltham, Que., to increase its capacity and maintain a higher head.

Construction was commenced during 1922 on a number of important projects throughout the province. At Gres falls, a short distance below Shawinigan falls, work was started during October on a new 125,000-horsepower development for the St. Maurice Power Company. This installation will comprise four units operating under a head of 65 feet and it is expected to have it in operation in 1925.

The Lower St. Lawrence Power Company commenced a 3,700-horsepower development near the mouth of the Metis river and work was well advanced by the end of the year. It is expected to have the plant in operation by July, 1923, and power will be supplied in the district extending from Matane to Rimouski.

Owing to increasing demands for power in the Eastern Townships area the Southern Canada Power Company expect to start construction on a new development at Hemming falls, on the St. Francis river, above Drummondville. This plant will have a capacity of 30,000 horse-power operating under a head of 50 feet.

In the Ottawa-Hull district two new developments are contemplated. The Ottawa and Hull Power and Manufacturing Company has had plans prepared for a development one mile below Bryson, Que., on the Calumet channel of the Ottawa river. The initial installation will comprise two units of 14,500 horsepower each with provision made for the addition of two larger units. The power will be transmitted to Ottawa and will also supply towns and villages on the way. The Hull Electric Company has completed surveys for a development at Paugan falls, on the Gatineau river, which will have an ultimate capacity of 100,000 horse-power under conditions of regulated river flow.

The largest project for which final definite arrangements have recently been made with the Quebec Government is that of the Quebec Development Company on the Saguenay river at the outlet of lake St. John. The present development is to have a capacity of 350,000 horse-power of which 200,000 horsepower is to be ready in five years. Lake St. John, whose storage possibilities have been thoroughly investigated by the Quebec Streams Commission, is to be used as a storage reservoir in connection with the project, a total storage depth of 10 feet on the lake being feasible.

The Quebec Streams Commission, whose work has proved of the greatest assistance to the proper development and use of the water-powers of the pro-

vince, has recently asked for tenders in connection with the Kenogami Lake Storage project to regulate the Chicoutimi and Sable rivers on which much power is utilized in the pulp and paper industry. The construction of this reservoir involves an expenditure of $2,500,000.

The Savanne reservoir, with a capacity of 30,000,000 cubic feet, on the Ste. Anne de Beaupre river, was completed by the Quebec Streams Commission in the latter part of 1922 at a cost of some $200,000 for the further regulation of the river flow at the St. Fereol power development.

Among other projects now in the hands of this commission are those of storage reservoirs for flow regulation on the Oureau, Gatineau and Metis rivers.

Summarizing the construction in the province for 1922, some 43,550 horsepower of new installation were added, 66,600 horse-power installed during 1921 were placed in operation and a number of very important projects were placed under way.

NEW BRUNSWICK

In New Brunswick the province carries on an active development policy through the New Brunswick Electric Power Commission. The first development undertaken by the commission on the Musquash river, near St. John, was completed and ready for operation by July, 1922, with an installation of 11,100 horse-power. Owing however to differences between the city of St. John and the New Brunswick Power Company the agency of its final distribution was not settled until December, 1922, when the city of St. John contracted with the New Brunswick Electric Power Commission to purchase energy up to 15,000,000 kilowatt-hours per annum at a price of 1·2 cents per kilowatt-hour. The city and the New Brunswick Power Company have not yet composed their differences with regard to the distribution of the power; the civic authorities in the meantime are making preparation to build their own distribution system. The city of Moncton had already contracted with the commission for 5,000,000 kilowatt hours per annum and the transmission line to that city was nearing completion at the close of 1922.

At Aroostook falls, on the Aroostook river, the Maine and New Brunswick Power Company commenced work on extensive alterations to their plant. Two new units of 2,000 horse-power each are to be installed and will replace two old units rated at 750 horse-power each. With the new units in place this plant will have a capacity of 8,400 horse-power. It is expected to have the alteration completed by August, 1923.

Investigatory studies were made by the New Brunswick Electric Power Commission of proposed developments on the Nepisiguit and Tetegouche rivers. It has also been lately reported that the commission have under consideration the development of Grand falls, on the St. John river.

NOVA SCOTIA

The Nova Scotia Power Commission formed in 1919 for the purpose of creating a complete electric power system for the province brought into operation in June, 1922, its 11,000-horsepower development at St. Margaret Bay. This plant has since been carrying the entire load of the city of Halifax and under the present peak conditions the city load is rapidly approaching its maximum capacity. Additional installation of 5,000 horse-power may be added to this development before its ultimate capacity is reached.

Among other hydro-electric installations made in Nova Scotia during 1922 may be mentioned a development of 84 horse-power on Tupper Lake stream by the Cambridge and Waterville Hydro-Electric Power Company to serve the towns of Cambridge and Waterville also the addition of a unit of 150 horsepower to the plant of the Gaspereau River Light, Heat and Power Company, Limited, on the Gaspereau river.

Preliminary construction was started in September by the Nova Scotia Power Commission on a new development at Malay falls, on East river, Sheet harbour. This development will have an initial installation of two 1,850-horsepower units with provision made for a third of the same capacity. Power will be transmitted to the towns of Pictou, Stellarton, New Glasgow, Trenton, and Westville. Tenders are being called for turbines and generators and it is expected to have the plant in operation early in 1924.

Plans for a development on the east branch of Bear river for the supply of the north shore of the province from Yarmouth to Middleton have also been prepared by the commission.

The Avon River Power Company has surveys under way for a small development on the Avon river to serve Windsor, N.S.

The activities throughout the Dominion are summarized in table 5.

Table No. 5.—List of Hydro-Electric Activities in 1922.

Plan No.	Company or Owner	Plant	Installation made 1921 and placed in operation 1922	New installations or additions 1922 H.P.	Total present installation	Installations under construction or actively projected
1	British Columbia Electric Railway Co.	Stave river		13,000	52,000	
2	East Kootenay Power Co., Limited	Bull river		7,200	7,200	
3	East Kootenay Power Co., Limited	Elk river, near Elko				16,000
4	Manitoba Power Co	Great Falls, Winnipeg river		28,000	28,000	28,000
5	City of Winnipeg	Point du Bois, Winnipeg river	6,900	6,900	67,100	
6	Backus-Brooks Co	Kenora		4,800	8,200	2,600
7	Dryden Paper Co	Wabigoon river				1,400
8	Town of Thessalon	Little Thessalon river		200	200	
9	Spruce Falls Co	Kapuskasing				2,500
10	Lower Sturgeon Power Co	Sturgeon falls, Mattagami river		4,000	4,000	4,000
11	Great Northern Power Co	Indian Chute, Montreal river				6,450
12	Hydro-Electric Power Commision of Ontario	Queenston-Chippawa, Niagara river	110,000	110,000	220,000	220,000
13	Canadian General Electric Co	Nassau, Otonabee river		1,300	2,700	
14	Hydro-Electric Power Commission of Ontario	Ranney falls, Trent river		10,000	10,000	
15	Ottawa and Hull Power and Manufacturing Co	Calumet falls, Ottawa river				30,000
16	Hull Electric Co	Paugan falls, Gatineau river				100,000
17	Cie. Electrique de Rockland	Blanche river		400	400	
18	Montreal Light, Heat and Power Consolidated	Cedars rapids, St. Lawrence river	22,600		152,200	45,200
19	Laurentide Power Co	Grand'Mère, St. Maurice river	44,000		164,000	
20	Shawinigan Water and Power Co	Shawinigan falls, St. Maurice river		43,000	191,500	
21	St. Maurice Power Co	Le Gres falls, St. Maurice river				125,000
22	Southern Canada Power Co	Hemming falls, St. Francis river				30,000
23	Cie. Electrique St. Prime	St. Prime		150	150	
24	Quebec Development Co	Saguenay river				350,000
25	Lower St. Lawrence Power Co	Metis river				3,700
26	Maine and New Brunswick Power Co	Aroostook falls			5,900	2,500
27	New Brunswick Electric Power Commission	Musquash river		11,100	11,100	
28	Cambridge and Waterville Hydro-Electric Power Co	Tupper lake		84	84	
29	Gaspereau River Light, Heat and Power Co	Whiterock, Gaspereau river		150	1,105	
30	Nova Scotia Power Commission	St. Margaret bay	10,820		10,820	
31	Nova Scotia Power Commission	Malay falls, East river, Sheet harbour				3,700
	Totals		194,320	240,284		971,050

NOTE.—In addition to the installations shown in the above table provision has been made in a number of existing plants for extensive additions as the loads increase. In addition also to the projected plants listed there are numerous other projects under study.

The Central Electric Station Industry of Canada

With the realization of the basic facts that improvement in the commercial efficiency of a country depends upon increasing the output of its workers, and that the logical manner of producing this increased output is by the greater use of mechanical power in industry, the importance of ample and economical supplies of readily available energy at once becomes apparent.

These supplies of power can best be provided by ample amounts of electrical energy and Canada with her widely distributed and advantageously located water-powers and generous deposits of fuel is particularly favoured in being able to produce power at very low cost. The production and distribution of this power is the function of the central electric station industry.

The greater commercial prosperity induced by the application of this low-priced power is in turn reflected in the earnings of the central stations themselves as the increased purchasing power of the individual makes itself felt in a greater demand for manufactured articles and for those amenities of modern civilization represented by improved lighting, heating, cooking and power-driven household appliances.

Under the terms of the co-operative agreement existing between the Dominion Water Power Branch and the Dominion Bureau of Statistics and as part of the census of industry conducted by the bureau, an annual census of the central electric station industry of Canada is taken. The fifth annual census has just been completed and an exhaustive analysis of the data gathered is being published in two sections, Part 1, presenting a general census and statistical digest of the industry as at January 1, 1922, together with the necessary explanatory text, and Part 2, comprising a comprehensive directory of all public or privately-owned organizations distributing electrical energy for sale, showing investment in plant and equipment, installation, mechanical equipment, service, location of power for sale, rates and transportation available.

While the data included in the Directory are based on the statistics of Part 1, it has been possible to include considerable later data, the date to which each particular description is complete being placed at its head.

Copies of Part 1 (Statistical) of this report may be obtained upon application to the Dominion Bureau of Statistics; for Part 2 (Directory) applications should be addressed to the Director of Water Power.

Summary of Statistical Data

An interesting summary of the principal items reported as affecting Canada and each of the provinces is set forth in table 6 below, and comparison of the figures therein with those of previous census shows that a remarkably healthy development is taking place in the industry.

Table No. 6.—Central Electric Stations—Summary, January 1, 1922

—	Canada	Alberta	British Columbia	Manitoba	New Brunswick	Nova Scotia	Ontario	Prince Edward Island	Quebec	Saskatchewan	Yukon
	1	2	3	4	5	6	7	8	9	10	11
Total number of stations	857	59	61	34	29	48	377	11	145	89	4
Of hydraulic stations	259	3	30	4	8	16	100	7	90	....	1
Of fuel stations	251	48	21	19	16	24	19	3	11	88	2
Of non-generating	347	8	10	11	5	8	258	1	44	1	1
Total Capital Invested	484,669,451	13,150,843	45,023,886	22,010,612	4,524,647	5,451,899	218,416,285	502,488	166,426,988	7,892,735	1,269,068
In lands, buildings and fixtures	193,711,524	4,270,045	19,876,667	6,613,949	1,689,465	1,296,194	83,426,456	38,400	74,870,914	980,898	648,536
In equipment	118,184,399	5,230,014	9,267,769	4,644,751	1,348,249	1,927,532	43,559,627	295,209	47,603,455	4,011,302	296,491
In distribution and transmission	111,858,623	3,113,793	12,447,980	9,421,702	1,026,633	2,002,882	62,354,535	114,070	18,742,667	2,536,898	97,463
In materials, supplies, etc	9,632,639	187,463	1,059 851	807,208	148,531	56,623	3,794,604	26,015	3,327,783	172,385	52,176
In cash trading, accounts, etc	51,282,266	349,528	2,371,619	523,002	311,769	168,668	25,281,063	28,794	21,882,169	191,252	174,402
Total Revenue from Sale of Power	73,376,580	3,030,117	7,108,408	3,148,012	1,222,781	1,749,025	35,147,501	104,309	19,337,581	2,435,037	93,809
For lighting purposes	28,797,359	2,025,853	3,229,765	2,162,896	839,911	1,326,934	10,307,642	90,636	7,029,102	1,726,412	58,208
For all other purposes	44,579,221	1,004,264	3,878,643	985,116	382,870	422,091	24,839,859	13,673	12,308,479	708,625	35,601
Total Value of Free Service	259,514	11,419	61,066	2,815	31,614	12,764	38,273	....	76,988	24,575	....
Total Expenses	47,044,503	1,882,523	3,441,378	2,125,641	825,965	1,547,964	23,270,442	84,300	11,987,782	1,803,692	74,816
Salaries and wages	15,234,678	746,189	1,213,754	1,181,561	256,678	476,104	7,642,306	32,214	3,016,295	634,490	35,087
Fuel	3,024,930	515,335	146,608	306,787	310,100	553,613	257,820	30,458	86,160	812,835	5,214
Miscellaneous	28,784,895	620,999	2,081,016	637,293	259,187	518,247	15,370,316	21,628	8,885,327	356,367	34,515
Total Number of Employees	10,714	441	731	742	257	385	5,309	31	2,374	422	22
Total Mileage of Pole Line	21,714	983	2,790	1,327	536	801	10,126	65	4,409	617	60
For transmission	7,922	208	866	324	74	159	4,115	21	2,055	51	49
For distribution	13,792	775	1,924	1,003	462	642	6,011	44	2,354	566	11
Total K.W.H. Generated (Thousands)	5,614,132	115,580	499,095	271,232	30,351	34,330	2,808,246	1,271	1,790,805	54,295	8,927
Total Number of Subscribers	973,212	52,070	89,806	68,721	20,979	35,244	401,954	3,282	264,441	36,306	409
Primary Equipment— Total primary power	1,997,857	80,106	213,819	85,362	21,048	25,070	827,408	1,775	662,131	50,918	10,220
Water Wheels and Turbines, No.	604	13	54	18	18	17	266	9	207	....	2
Total H.P.	1,826,357	32,380	207,201	82,725	9,513	3,867	824,653	288	655,730	....	10,000
Steam Reciprocating Engines, No.	187	51	18	14	18	33	16	2	13	21	1
Total H.P.	45,450	13,028	3,653	1,695	5,350	9,333	2,045	500	3,870	5,916	60

Table concluded on p. 26

Table No. 6.—Central Electric Stations—Summary, January 1, 1922—Concluded

—	Canada	Alberta	British Columbia	Manitoba	New Brunswick	Nova Scotia	Ontario	Prince Edward Island	Quebec	Saskatchewan	Yukon
	$	1	3	4	5	6	7	8	9	10	11
Steam Turbines, No.	43	11	1	....	5	10	....	....	2	13	1
Total H.P.	90,705	32,950	900	....	5,075	11,545	....	....	2,275	37,800	160
Gas and Oil Engines, No.	203	30	16	15	7	5	10	6	7	107	....
Total H.P.	15,345	1,748	2,065	942	1,110	325	710	987	256	7,202	....
Secondary Equipment— Total secondary power	1,475,610	61,092	139,506	69,063	14,901	19,813	613,348	1,479	505,663	44,565	6,180
Dynamos A.C., No.	841	72	80	35	40	55	260	13	205	78	3
Total K.V.A.	1,464,022	58,135	138,362	68,854	14,042	18,008	612,357	1,468	503,713	42,933	6,150
Dynamos D.C., No.	172	29	14	10	7	12	18	2	14	64	2
Total K.V.A.	11,588	2,957	1,144	209	859	1,805	991	11	1,950	1,632	30

During the five years which have elapsed since the taking of the first census the number of stations has increased from 666 to 857, the capital invested from $356,004,168 to $484,669,451, the revenue from sale of power from $44,536,848 to $73,376,580, and the total primary power installation from 1,844,571 horse-power to 2,111,419 horse-power.

The relationship of public to private ownership of public utilities is evidenced by the fact that whereas in the first census municipally owned stations exceeded privately owned by 3 per cent of the total number, this excess has now grown to 12 per cent. While many of these municipally owned stations are very small, being designed to meet only local conditions, an idea of the extent of their business may be gained from the fact that 506,977 subscribers or over 50 per cent of the total of 973,212 are served by them. This comparison, of course, does not convey an accurate impression of the relative installations of the two classes of stations as most of the large industrial power users are served by the privately owned stations. This is indicated by the fact that the primary power installation of the commercial stations amounts to 1,571,710 horse-power, as against 539,709 horse-power in municipal stations, the electrical output of the two classes being respectively 4,316,272 and 1,297,860 thousands of kilowatt-hours.

PREDOMINANCE OF WATER-POWER IN CENTRAL ELECTRIC STATIONS

In table 7 is presented a comparison of data showing the extent to which the economy and ready adaptability of water-power to the generation of electricity has led to its utilization.

Table No. 7.—Central Electric Stations—Comparison

Provinces	No. of Stations			Capital Invested			Revenue from Sale of Power		
	Total	Hydro	Fuel	Total	In Hydro Stations	In Fuel Stations	Total	By Hydro Stations	By Fuel Stations
1	2	3	4	5	6	7	8	9	10
				$	$	$	$	$	$
Canada	857	588	269	484,669,451	455,193,498	29,475,953	73,376,580	63,622,279	9,754,301
Alberta	59	6	53	13,150,843	5,341,882	7,808,961	3,030,117	463,634	2,566,483
British Columbia	61	39	22	45,023,886	43,967,222	1,056,664	7,108,408	6,719,220	389,188
Manitoba	34	13	21	22,010,612	21,455,208	555,404	3,148,012	2,920,602	227,410
New Brunswick	29	11	18	4,524,647	1,571,443	2,953,204	1,222,781	247,546	975,235
Nova Scotia	48	19	29	5,451,899	976,263	4,475,636	1,749,025	172,438	1,576,587
Ontario	377	357	20	218,416,285	218,032,357	383,928	35,147,501	35,012,272	135,229
Prince Edward Island	11	8	3	502,488	79,186	423,302	104,309	9,246	95,063
Quebec	145	133	12	166,426,988	162,531,350	3,895,638	19,337,581	17,991,748	1,345,833
Saskatchewan	89	....	89	7,892,735	....	7,892,735	2,435,037	....	2,435,037
Yukon	4	2	2	1,269,068	1,238,587	30,481	93,809	85,573	8,236

NOTE.—

I. In addition to the water-wheels and turbines included in column 12 the Hydraulic Station organizations maintain fuel auxiliary or stand-by equipment aggregating 133,562 h.p., or an amount equal to 88·2 per cent of the main fuel station installation.

II. Under Hydro and Fuel Stations, in columns 3, 4, 6, 7, 9 and 10, are included details of all non-generating stations buying power in bulk for resale from Hydro and Fuel generating stations respectively.

III. As some of the smaller stations are unable to report their K.W.H. output the figures relating thereto only include the stations reporting.

of Data—Water versus Fuel—January 1, 1922.

Total Primary Power			Electrical Energy Generated			Average Revenue per K.W.H.			Average K.W.H. Generated per K.V.A.		
Total	In Hydro Stations	In Fuel Stations	Total	In Hydro Stations	In Fuel Stations	Of all Gen. Stations	Of Hydro Gen. Stations	Of Fuel Gen. Stations	All	In Hydro Stations	In Fuel Stations
11	12	13	14	15	16	17	18	19	20	21	22
H.P.	H.P.	H.P.	1000's of K.W.H.	1000's of K.W.H.	1000's of K.W.H.	cents	cents	cents	K.W.H.	K..W.H	K.W.H.
1,977,857	1,826,357	151,500	5,614,132	5,447,582	166,550	·9005	·7607	5·4747	3,725	3,921	1,412
80,106	32,380	47,726	115,580	66,000	49,580	2·4382	·6857	4·7711	1,887	2,719	1,341
213,819	207,201	6,618	499,095	491,023	8,072	·8887	·8307	4·4164	3,148	3,193	1,691
85,362	82,725	2,637	271,232	269,666	1,566	1·0175	·9550	11·7892	3,444	3,499	937
21,048	9,513	11,535	30,351	14,014	16,337	3·9303	1·6217	5·9106	2,069	2,080	2,059
25,070	3,867	21,203	34,330	1,722	32,608	4·3957	4·6721	4·3811	1,934	1,252	1,992
827,408	824,653	2,755	2,808,246	2,807,338	908	·6616	·6598	6·4339	4,475	4,479	1,172
1,775	288	1,487	1,271	53	1,218	7·8909	9·8698	7·8048	988	384	1,061
662,131	655,730	6,401	1,790,805	1,788,880	1,925	·9364	·8690	68·7583	3,599	3,628	423
50,918	....	50,918	54,295	....	54,295	4·2952	....	4·2952	1,245	....	1,245
10,220	10,000	220	8,927	8,886	41	·6599	5·702	20·0878	1,444	1,481	228

Of the total main plant primary power installation of 1,977,857 horse-power, 1,826,357 horse-power, or 92·4 per cent, representing slightly over 94 per cent of the total capital investment and over 97 per cent of the electrical output, are installed in hydraulic generating stations. In addition these hydraulic generating organizations maintained fuel-auxiliary or standby equipment aggregating 133,562 horse-power, or an amount equal to 88·2 per cent of the main fuel station installation, to supplement the output of the hydro-electric stations during periods of excessive demand or shortage of power due to accidents, insufficient water or similar causes.

Perhaps the most significant figures of the table from the standpoint of the power consumer are found in columns 18 and 19, where the average revenue per kilowatt-hour, i.e., the unit price to the user, of power produced from water and fuel are set against each other. When it is noted that the average revenue per kilowatt-hour from power distributed by hydro-electric generating organizations is only ·7607 cent, as compared with 5·4747 cents received by the fuel generating stations, the great economy of water-power at once becomes apparent In addition, the fact that the use of water-power in no way impairs the supply while fuel once consumed is gone forever is of prime importance.

The average kilowatt-hour output per unit of generator capacity reporting also shows the wide difference in application of electricity produced by water and fuel-power. The average utilization of equipment is highest in those provinces where the use of water-power predominates, attaining a maximum in Ontario, where 4,700 kilowatt-hours were produced by each kilo-volt ampere of generator capacity reported, representing 54 per cent of maximum utilization.

An outstanding feature of this census is the large number of existing hydro-electric stations which report contemplating the installation of additional equipment, a total of 92,540 horse-power being so reported. In addition, a considerable number of new stations have been installed, the records of this branch showing that there has been an addition to the hydraulic central electric station installation of 378,129 horse-power during the year 1922.

Dominion Hydrometric Survey

The Dominion Hydrometric Survey has during the past year become national in scope, embracing all the provinces in the Dominion. Other than the Prairie Provinces, where the work is a direct responsibility of the Federal Government, co-operative agreements for such work have been entered into from time to time with individual provinces, until with the consummation on October 1, of such an agreement with the Quebec Streams Commission, all the provinces were comprehended in the surveys activities. This consolidation of hydrometric investigation has rendered most effective both the gathering and dissemination of stream flow data. Methods throughout have been standardized, with a consequent natural gain in efficiency and an overall saving in administration, together with the added valuable factor of making available to the public water resources information at one central source.

The ever-increasing utilization of water resources for diversified and often conflicting purposes has given rise to a most pressing demand for detailed and extensive records of the regimen of the various lakes and rivers of the country, and particularly has this been evident in connection with power development and irrigation projects. Probably in no greater manner is recognition given the importance of stream flow records than in the material voluntary co-operation afforded the survey by numerous individuals and private corporations.

With consolidation of the hydrometric survey, it has been possible to so rearrange both field activities and office administration as to ensure the most efficient prosecution of the work. For purposes of field operation and publication of records, the past arbitrary divisions of provincial boundaries have been eliminated, and the logical and natural divisions of major drainage basins insti-

tuted. The main drainage basins into which the country has been divided together with the location of the district office or offices in charge are as follows: Pacific drainage, Vancouver; Arctic and western Hudson Bay drainage, Calgary and Winnipeg; St. Lawrence and southern Hudson Bay drainage, Ottawa and Montreal; Atlantic drainage, Halifax.

RUN-OFF CONDITIONS IN CANADA

With the exception of southeastern Saskatchewan, southern Manitoba and the Maritime Provinces, the average run-off for the year as shown in detail in the reports of the district chief engineers was slightly below normal. The distribution of run-off throughout the year was, however, at variance with average conditions; in the major portion of the country flood inflow exceeded the average while run-off during the autumn was deficient.

In the Pacific drainage, stations typical of general run-off conditions indicated a run-off of 95 per cent of the average. Flood run-offs while not abnormal exceeded the mean by from 5 per cent to 50 per cent, whereas deficiencies in other months ranged from 20 per cent to 30 per cent below the mean.

Run-off in the Arctic and western Hudson Bay drainage with the exception of the Assiniboine river basin, ranged from 50 per cent to 90 per cent of normal. In the Assiniboine basin and adjacent smaller basins to the north excessive spring floods were encountered and the average for the year was 200 per cent of the mean of previous years.

In the St. Lawrence and southern Hudson Bay drainage, comparative records are only available for drainage within the province of Ontario where the average for the year ranged from 70 per cent to 97 per cent of the mean.

Run-off in the Atlantic drainage as comprising the Maritime Provinces was exceptional as compared with the other drainages. Flows 200 per cent of the normal during summer months raised the average for the year above that of other years.

Power and Storage Investigations

Owing to the need for careful apportionment of field expenditures, power and storage investigations were undertaken during the past year only where urgent conditions demanded. In the head office, however, and in the various field offices the analysis was continued of the developed and undeveloped water-power resources of the Dominion. This work was carried on in co-operation with the provincial authorities in British Columbia, Ontario, Quebec, and the Maritime Provinces, where administration of water-powers is purely a provincial responsibility.

In British Columbia a special study was commenced of the run-off data of certain streams in connection with proposed power scheme supplying the city of Vancouver. The analysis of the water-power resources of the province was actively carried forward in co-operation with the Provincial Water Rights Branch.

In Alberta attention was given an application to develop power on the Crowsnest river and an interim license recommended. An inspection was made of a small water-power site on Cranberry creek and an investigation also made of the condition of a dam at the outlet of Gull lake formerly used for power. Responsibility for the operation of the lake Minnewanka storage during the filling seasons was again assumed by the department with very satisfactory results to all concerned. In connection with the power possibilities of the Bow River basin, office studies were made of dependable outflow from Spray lakes and lake Minnewanka.

In Manitoba an investigation was made in connection with an application to develop a small water-power site on Peterson creek, a tributary of the Bird

river. In co-operation with the Geodetic Survey of Canada a series of permanent bench-marks were established at all strategic points along the Winnipeg and English rivers.

In Ontario surveys were made at the outlets of the lake of the Woods at the request of the Lake of the Woods Control Board for the purpose of ascertaining the best methods of obtaining a better control and regulation of the lake. In connection with the analysis of the water-power resources of the province, office studies were continued in co-operation with the provincial authorities.

In Quebec, following the co-operative agreement between this branch and the provincial authorities, an exhange of water-resources data was made and the analysis of the developed and undeveloped powers of the province was actively carried forward.

In New Brunswick active co-operation was maintained with the New Brunswick Electric Power Commission and investigations were carried out on the Digdeguash and two other small streams near St. George; also an investigation was commenced at Grand falls, on the St. John river.

In Nova Scotia co-operation was maintained with the Nova Scotia Power Commission and investigations were made on the Economy river, Fales river near Kingston, Mulgrave brook and Pirates Cove brook near Mulgrave, river John near River John and Tupper Lake brook near Waterville. Office studies were made of a number of projects actively under consideration.

Flooded Land Surveys

The work of fixing a boundary for the area to be reserved for power purposes along the Winnipeg river, which was commenced in 1919 and continued in 1920 and 1921, was this year extended so as to include that section of the river between McArthur Falls site and the power development now under construction at Great falls. In addition to the survey of the Great Falls section a survey was made of that portion of the river extending from the lower Seven Sisters site in section 5, township 14, range 11, E.P.M., to the east boundary of sections 27 and 34 in township 13, range 11, E.P.M.

The survey of the power reserve in the Great Falls section was commenced at the north boundary of sections 34 and 35 in township 16, range 11, E.P.M., and extended northward to near the north boundary of section 27, township 17, range 11, E.P.M. The retracement survey was closed on the northeast corner of section 34, township 17, range 11, E.P.M. The location of the boundary of the power reserve involved the survey of contour 814 feet. For this purpose elevations were taken throughout the district and a traverse was run near the contour. The courses were measured by means of a transit and chain. The boundaries of the sections intersected by the traverse were surveyed and the traverse was closed on the section lines.

In the traverse of the west side of the Great Falls section there is a break in the contour at T.H.18 to T.H.21, at T.H.28 to T.H.29 and at T.H.38 to T.H.44. The summit here is below elevation 814 feet and if the water surface is raised to elevation 805 feet or over dyking will be necessary. The average fill necessary to raise the ground surface to elevation 814 feet will be 6·5 feet and the length of the embankment will be 10,550 feet along the railway in addition to the two smaller fills aggregating 1,000 feet in length and 3 feet in height. If the railway grade be used as a dyke the same results would be obtained by raising the grade an average of 3 feet for a distance of 9,000 feet in addition to the two smaller dykes mentioned above.

In the Great Falls survey 40 miles of traverse and 25 miles of section lines were run.

The work at the lower Seven Sisters site was commenced on the north boundary of section 5, township 14, range 11, E.P.M., and closed on the east boundary of sections 27 and 34 in township 13, range 11, E.P.M. Contour 875 feet was traversed on both sides of the Winnipeg river and the boundaries of the sections crossed by the traverse were resurveyed in the usual manner. No attempt was made, however, to locate this contour along the Whitemouth river which enters the Winnipeg river from the south in section 28-13-11-E.P.M.

The banks of the Winnipeg river just below the lower falls are very high and being of clay are, in some places, very unstable. Immediately below the junction of the Whitemouth with the Winnipeg the south bank is about 50 feet above the water.

In the lower Seven Sisters district 15 miles of traverse and 15 miles of section lines were surveyed. The posting of this section was not completed owing to low-water in the river which prevented the transport of supplies and necessitated closing down the work earlier than was expected.

Publications

The publications of the branch, which make available to the public the results of investigations and hydrometric and water-power data obtained by the various engineers, consist of Annual Reports, Water Resources Papers and special pamphlets and bulletins. A list of the Annual Reports and Water Resources Papers published to date will be found at the end of this report, and copies will be sent on application to those interested, free of charge. The reports, etc., listed hereunder were prepared and published during the year or were in course of preparation.

Reports Published.

1. Annual Report of the branch for the fiscal year 1921-22.
2. Water Resources Paper No. 31.—Surface Water Supply of Canada. Report on hydrometric surveys covering the Arctic and western Hudson Bay drainage (and Mississippi drainage in Canada) in Alberta, Saskatchewan, Manitoba, extreme western Ontario and the Northwest Territories, for the climatic year ending September 30, 1920, by C. H. Attwood, district chief engineer, Winnipeg, and A. L. Ford, district chief engineer, Calgary.
3. Water Resources Paper No. 32.—Water Resources Index Inventory by J. T. Johnston. Description of the Index Inventory System for recording and collating the water resources data of the Dominion.
4. Water Resources Paper No. 34.—Surface water supply of Canada. Report on hydrometric surveys covering the St. Lawrence and southern Hudson Bay drainage in Ontario for the climatic year ending September 30, 1921, by S. S. Scovil, district chief engineer.
5. Water Resources Paper No. 35.—Surface water supply of Canada. Report on hydrometric surveys covering the Pacific drainage in British Columbia and the Yukon Territory for the climatic year ending September 30, 1921, by R. G. Swan, district chief engineer.

Bulletins Published.

1. The national importance of water-power to Canada.
2. Hydro-electric progress in Canada, January, 1923.
3. Water-power Resources of Canada, February 1, 1923.

Reports now in Press.

1. Annual Report of the branch for the fiscal year ending March 31, 1922.
2. Water Resources Paper No. 33.—Directory of Central Electric Stations in Canada. Comprises an analysis of the water-power statistics and a directory of the central electric stations as at November 1, 1922.
3. Water Resources Paper No. 36.—Surface water supply of Canada. Report on hydrometric surveys covering the Arctic and western Hudson Bay drainage (and Mississippi drainage in Canada) in Alberta, Saskatchewan, Manitoba, extreme western Ontario and the Northwest Territories, for the climatic year ending September 30, 1921, by C. H. Attwood, district chief engineer, Winnipeg, and A. L. Ford, district chief engineer, Calgary.

Reports in Course of Preparation.

1. Water Resources Paper No. 37.—Surface water supply of Canada. Report on hydrometric surveys covering the Atlantic drainage south of the St. Lawrence river, including Nova Scotia, New Brunswick and Prince Edward Island, and southwestern Quebec, for the climatic years ending September 30, 1921, and September 30, 1922, by K. H. Smith, district chief engineer.
2. Water Resources Paper No. 38.—Surface water supply in Canada. Report on hydrometric surveys covering the St. Lawrence and southern Hudson Bay drainage in Ontario for the climatic year ending September 30, 1922, by S. S. Scovil, district chief engineer.
3. Water Resources Paper No. 39.—Surface water supply of Canada. Report on hydrometric surveys covering the Pacific drainage in British Columbia and the Yukon Territory for the climatic year ending September 30, 1922, by R. G. Swan, district chief engineer.
4. Water Resources Paper No. 40.—Surface water supply of Canada. Report on hydrometric surveys covering the Arctic and western Hudson Bay drainage (and Mississippi drainage in Canada) in Alberta, Saskatchewan, Manitoba, extreme western Ontario and the Northwest Territories for the climatic year ending September 30, 1922, by C. H. Attwood, district chief engineer, Winnipeg, and A. L. Ford, district chief engineer, Calgary.

Further reference should be made to the Directory of Central Electric Stations in Canada, Water Resources Paper No. 33, listed above. The first edition of this publication was issued in 1919 in order to meet the frequent inquiries respecting the location, price and transportation facilities affecting available blocks of developed electrical energy and to present a comprehensive review of the scope and character of the industry. The rapidly changing conditions in the industry and the exhaustion of the first issue compelled the preparation of a new edition, which is now almost ready for distribution. While following the general lines of the first Directory it has been possible to present considerable additional data, notably in connection with the transmission and distribution of power. Maps of all the principal transmission systems are included, as well as details of the distribution systems in those municipalities where power purchased in bulk by non-generating organizations is distributed for sale.

The Directory presents definite information as at November 1, 1922, in regard to all Central Electric Stations in Canada, of organization, officials, capitalization, history, primary and secondary power installation, transmission

and distribution systems, municipalities served, electrical output, load conditions, use of power, blocks of power for sale, rates and available transportation, and should prove a valuable source of reference to trade commissioners and engineering, financial and manufacturing organizations.

Drafting and Photography

The work done in the drafting division during the year touched on most of the activities of the branch embodied in this report. Among the more important plans, maps, etc., prepared were those in connection with the water resources index inventory; lake of the Woods control; water-power in relation to railways, the pulp and paper industry, the mining industry and Canada's fuel problem; research; census of central electric stations; St. Lawrence river improvement scheme; international waterways problems; hydrometric, water-power and Dominion lands surveys; and water-power construction. There were also prepared for publication a series of plans showing the electric transmission systems throughout Canada, index maps showing location of gauging stations and numerous other individual plans and diagrams to accompany branch publications.

The motion-picture films of the water-powers tributary to Montreal, Winnipeg, Calgary and Vancouver, as well as the collection of lantern slides of water-powers of Canada, have been in continual demand during the year. They have been shown before many technical, educational and other representative bodies, and have always been very much appreciated. There has also been a constant demand for photographic prints of water-power plants, power sites, etc., for reproducing in engineering and other technical reports and papers.

PART 2

FIELD REPORTS

PART II

FIELD REPORTS

DISTRICT OF BRITISH COLUMBIA

R. G. Swan, District Chief Engineer.

During the fiscal year ending March 31, 1923, regular stream measurement investigatory operations of the Dominion Water Power Branch in the province of British Columbia have been continued as formerly, consistent with the terms of the co-operative agreement of August, 1913, between the Department of the Interior at Ottawa and the Provincial Government. This agreement was subsequently ratified by the Provincial Legislature and the Dominion Government.

ORGANIZATION

The work in British Columbia is directed from the district office at Vancouver with a branch office at Kamloops. For purpose of administration and convenience of field operations, the territory covered was divided into districts as explained in previous reports. While the primary object of this district organization is the acquiring and tabulating of stream flow data for purposes of power development, irrigation, domestic water supply, etc., the services of the engineers of this staff are frequently utilized by other Dominion Government departments which are without engineers in the province, in connection with investigations which require hydraulic engineering knowledge. The greatest amount of work for outside departments was that performed for the Department of Indian Affairs in connection with the investigation of their water rights, which necessitated the maintenance of an engineering party in the field continuously throughout the season as well as an engineer to look after the Indians' interests before the Board of Adjudication under the Water Act.

CO-OPERATION

As already referred to, all hydrometric studies in British Columbia are made under the co-operative agreement with the Provincial Government and every effort is made to meet the requests of the Comptroller of Water Rights for stream flow data. Stations were maintained on the Columbia, Pend d'Oreille, and Skagit rivers, very important international streams, in co-operation with the Water Resources Branch of the United States Geological Survey.

In connection with the water records appurtenant to Indian reserves, a report of the Williams Lake Agency was completed and a copy submitted to the Board of Investigation. This report completes the series of five which deals with the Indian claims to water rights in British Columbia.

Claims to water for reserves situated in the Nicola valley, outside the Railway Belt, were reheard by the Board of Adjudication under the Water Act at Merritt, B.C., on May 11, under the Indian Water Claims Act, which was passed at the second session of the Provincial Legislature in November, 1921. A special meeting was also held at Ashcroft on August 4, for the purpose of hearing claims of the Department of Indian Affairs to an apportionment of records granted to Messrs. Cornwall Brothers of Ashcroft in 1865 and 1877 for water from Cornwall creek, McLeans lake and tributaries, also Medicine creek. Although considerable opposition was encountered, the claims were sustained by the board and these records were held to be appurtenant to the land which now forms Ashcroft Indian Reserve No. 4.

Claims for Okanagan Indian Reserve No. 7—Duck lake—necessitated a special hearing at Vernon on August 7, under the Indian Water Claims Act. In this case also the claims of the department were allowed by the board.

In the fall of 1922 the branch was approached by the city of Vancouver through their consulting engineer, Mr. J. G. G. Kerry, to undertake certain stream flow investigations in connection with the possible development of hydro-electric power for the city.

HYDROMETRIC SURVEYS

During the climatic year ending September 30, 1922, 214 regular gauging stations were maintained on rivers and tributaries in the following main watersheds: Columbia, Fraser, Kettle, Kootenay, North Thompson, Okanagan, Pacific Coast (Mainland), Similkameen, Skagit, South Thompson, Thompson and Vancouver Island. Of the above stations, 58 were maintained for power, 150 for irrigation, 10 for drainage and reclamation, 7 for domestic water supply, 4 for flood purposes, 6 for navigation, 15 for international problems, and 4 for statistical purposes. A number of these stations were maintained for several purposes. Since September 30, 54 stations have been discontinued. Records for the majority of these streams have been secured for a number of years when, however, it became necessary to curtail our work in order to keep within the appropriation, those for which we had longest records and also those which were considered of least immediate importance, were discontinued.

The total run-off for the year ending March 31, 1923, was below normal. Four typical gauging stations have been selected for Pacific drainage as follows: Seymour creek near Vancouver, Bridge river, North Thompson at Barriere and Kootenay river at Wardner, and meteorological records have been compiled for each locality as follows:—

Station Number	River	Meteorological Station
$8GA_{13}$	Seymour creek	Vancouver.
$8ME_{1}$	Bridge river	Pemberton hatchery.
$8LB_{22}$	North Thompson river	Kamloops.
$8NG_{5}$	Kootenay river	Baynes lake.

The meteorological records at these stations are purely local and cannot be taken to represent conditions obtaining elsewhere in the watersheds. This is especially true in British Columbia where climatic conditions change rapidly in short distances. However, in a very general way they are interesting in the study of run-off conditions.

The precipitation for the year was below normal. Steady warm weather during the end of May and the first part of June at the coast caused abnormally high water. At the Seymour Creek station the discharge for the month of May was 28 per cent above the average while the discharge for June was 50 per cent greater than the average for that month over a nine-year period. These conditions are reflected throughout British Columbia for the month of June.

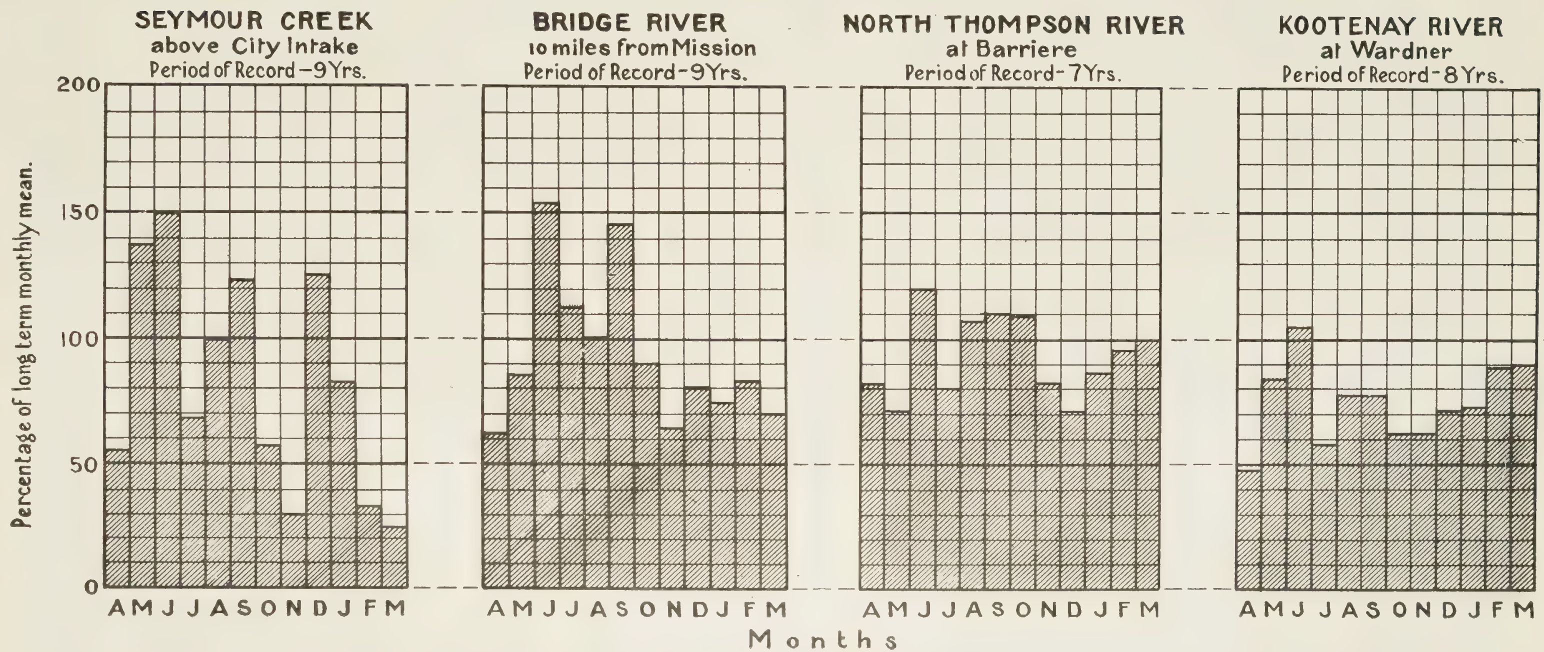
With temperature and precipitation below normal particularly at the coast, the monthly discharges for February and March have been below the average monthly discharge for the past nine years. Monthly discharge on Seymour creek for March is only 26 per cent of average while that on Bridge river is 70 per cent. The monthly discharge on the North Thompson river is the nearest to normal. On the Kootenay river at Wardner, with the exception of the month of June when the discharge was 105 per cent of the average, the accompanying graph shows the monthly discharges to be below normal. These conditions were due to the small snow storage in the Rocky mountains at the headwaters of the Kootenay river, during the previous winter months.

PLATE I

MEAN MONTHLY RUNOFF OF TYPICAL WATERSHEDS IN BRITISH COLUMBIA

FOR YEAR 1922-23

RUNOFF SHOWN AS PERCENTAGE OF LONG TERM MONTHLY MEAN



In the coast area the typical station (Seymour creek) had a maximum discharge for the year of 7,000 second-feet on December 27. The minimum of 80 second-feet occurred on December 11. The maximum discharge recorded at this station since 1914 is 23,200 second-feet in October, 1921, and minimum of 41 second-feet in September, 1915. During the year the month of June had the greatest run-off per square mile, 20·30 second-feet. The least occurred in March, 2·01 second-feet, the mean for the year being 8·33 second-feet per square mile.

In the central Fraser River basin the typical station (Bridge river) had a maximum discharge of 20,300 second-feet in July and minimum of 410 second-feet in December. The maximum discharge recorded at this station since 1914 is 26,000 second-feet in June, 1918, and minimum of 360 second-feet in November, 1918. During the year the month of July had the greatest run-off per square mile, 6·84 second-feet. The least occurred in March, 0·24 second-foot, the mean for the year being 2·20 second-feet per square mile.

In the North Thompson River basin the typical station (North Thompson at Barriere) had a maximum discharge of 65,300 second-feet in June and minimum of 2,130 second-feet in January. The maximum discharge recorded at that station since 1915 is 97,000 second-feet in June, 1922, and minimum of 1,500 second-feet in March, 1919. During the year the month of June had the greatest run-off per square mile of 6·68 second-feet. The least occurred in March of 0·35 second-foot, the mean for the year being 1·83 second-feet per square mile.

Meteorological Records in Pacific Drainage—British Columbia and Yukon Territory—for the year ending March 31, 1923

VANCOUVER, B.C.

	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.
Mean temperature	46·0	53·8	61·8	64·0	62·3	56·7	51·0	41·0	33·7	36·5	34·9
Average mean temperature	47·3	53·7	58·7	63·0	62·1	56·2	49·3	42·5	38·1	35·6	37·9
Difference	− 1·3	0·1	3·1	1·0	0·2	0·5	1·7	− 1·5	− 4·4	0·9	−3·0
Precipitation	2·63	2·46	0·17	0·02	0·02	5·76	3·26	2·63	10·35	8·73	4·06
Average precipitation	3·30	2·95	2·59	1·31	1·74	4·12	5·83	9·68	7·95	8·34	4·90
Difference	− 0·67	− 0·49	− 2·42	− 1·29	0·27	1·64	− 2·57	− 7·05	2·40	0·39	−0·84

PEMBERTON HATCHERY

	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.
Mean temperature	43·7	52·5	62·8	66·7	64·3	56·6	47·8	35·1	22·8	27·3	25·6
Average mean temperature	45·4	52·7	58·5	64·2	64·0	55·2	46·0	36·0	27·6	23·3	28·8
Difference	− 1·7	− 0·2	4·3	2·5	0·3	1·4	1·8	− 0·9	− 4·8	4·0	−3·2
Precipitation	1·63	0·65	0·08	0·43	0·99	4·26	1·71	1·75	4·41	4·55	19·5
Average precipitation	1·42	1·32	1·46	0·97	1·51	2·51	3·77	5·82	3·54	4·11	2·41
Difference	0·21	− 0·67	− 1·38	− 0·54	− 0·52	1·75	− 2·06	− 4·07	0·87	0·44	−0·46

KAMLOOPS, B.C.

	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.
Mean temperature	47·4	56·8	68·5	70·8	67·7	61·5	48·1	35·5	17·7	26·0	23·3
Average mean temperature	49·3	57·5	64·1	69·5	68·0	58·1	47·5	35·5	27·7	21·8	26·0
Difference	− 1·9	− 0·7	4·4	1·3	− 0·3	3·4	0·6	0·0	−10·0	4·2	−2·7
Precipitation	0·78	0·19	0·12	0·56	1·36	0·66	1·25	0·23	1·18	0·30	0·45
Average precipitation	0·39	0·98	1·24	1·10	1·07	0·83	0·62	0·94	0·85	0·87	0·74
Difference	0·39	− 0·79	− 1·14	− 0·54	0·29	− 0·17	0·63	− 0·71	0·33	− 0·57	−0·29

BAYNES LAKE

	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.
Mean temperature	38·9	47·9	61·5	64·2	....	56·0	41·6	26·9	9·6	23·1	12·9
Average mean temperature	42·2	48·6	56·6	65·1	....	53·7	40·6	29·7	18·8	18·0	21·7
Difference	− 3·3	− 0·7	4·9	− 0·9	....	2·3	1·0	− 2·8	− 9·2	5·1	−8·8
Precipitation	0·57	0·65	0·52	0·95	....	1·00	1·15	1·30	2·78	1·64	0·80
Average precipitation	1·40	0·97	1·76	0·99	....	1·75	0·64	1·16	2·29	1·54	1·36
Difference	− 0·83	− 0·32	− 1·24	− 0·02	....	− 0·75	0·51	0·14	0·49	0·10	−0·56

In the upper Kootenay River basin the typical station (Kootenay at Wardner) had a maximum discharge of 42,800 second-feet in June and minimum of 1,250 second-feet in March. The maximum discharge recorded at this station since 1914, is 67,500 second-feet in June, 1916, and minimum of 1,230 second-feet in March, 1922. During the year the month of June had the greatest run-off per square mile of 5·25 second-feet. The least occurred in February and March of 0·24 second-foot, the mean for the year being 1.15 second-feet per square mile.

SPECIAL INVESTIGATIONS

During the year special run-off studies have been commenced in connection with the city of Vancouver power investigations on the following streams: Cheakamus, Green, Lillooet, Harrison, Chehalis and Pitt. All capital expenditures are being met by the city.

In connection with the work of the Indian Affairs Department, approximately 30 investigations were made and plans and reports submitted covering storage and irrigation projects appurtenant to Indian reserves in the interior agencies. Construction work resulting from these investigations was carried out on Niskonlith No. 1 reserve, Sahhaltkum No. 4 and 4A reserves, and a control dam installed at the outlet of Mamette lake.

Investigations were carried out in connection with a domestic water supply system for the Sliammon and Church House Indian reserves, also for the Alberni and St. Eugene industrial schools. A complete system of fire protection was installed for the Sliammon Indian reserve and improvements carried out to the St. Eugene and Alberni industrial school systems.

An inspection and report was submitted on an application to cut shingle bolts in township 4, range 5, west 7th meridian. The land in question lying within the reserve set aside for the protection of water supply for the municipality of Maple Ridge.

An investigation and report was submitted to the Indian Affairs Department in connection with the erosion of the Seachim Indian reserve caused by the action of the Squamish river.

With financial conditions returning more nearly to normal than they have been since the war, much more interest is being taken in the development of the country. Improved conditions are clearly reflected in the number of inquiries for data during the past year, particularly on power and irrigation streams.

Altogether data has been supplied to individuals, corporations and government departments on 110 gauging stations, divided as follows: 50 for power investigations, 30 for irrigation projects, 16 for lake and river control, 11 for administration and 3 for domestic water supply.

CONSTRUCTION

It is of interest to record a revival of activity in water-power construction throughout the province during the past year following the more or less inactive period subsequent to the war. A new 7,200-horsepower development was placed in operation by the East Kootenay Power Company on the Bull river and a commencement made on another of 24,000 horse-power by the same company on the Elk river near Elko. Works to increase storage capacities were carried out by the Western Power Company of Canada at Stave lake, by the Granby Consolidated Mining and Smelting Company on Falls creek and by the Pacific Mills, Limited, at Ocean falls. Additional power capacity of 13,000 horse-power was installed at the Stave Falls plant of the Western Power Company of Canada. A small installation was made by the town of Agassiz on McDonald creek for domestic consumption. Among active prospective developments may be mentioned one on the Adams river from which the city of Kamloops may secure a block of power, also one for the Coast Copper Company on Raging river, Vancouver island.

DISTRICT OF ALBERTA AND SASKATCHEWAN

A. L. Ford, District Chief Engineer

During the fiscal year ended March 31, 1923, the regular stream measurement and power investigatory operations of the Dominion Water Power Branch in the provinces of Alberta and Saskatchewan have been continued.

The scope of the work covered by this district organization comprises the hydrometric survey and the power and storage investigatory work in the two provinces, including the Peace River Block in British Columbia but excluding the Churchill river area in northern Saskatchewan.

ORGANIZATION

Stream measurement work started in these provinces in 1894 and was continued on a small scale by the Canadian Irrigation Surveys until 1909. From 1909 to 1911 the Hydrometric Survey was under the Forestry and Irrigation Branch of the department and from 1911 to 1920 under the Irrigation Branch. On July 1, 1920, it was transferred to the Dominion Water Power Branch and has since continued under that branch.

The stream measurement operations are now controlled from the district office at 513 Eighth avenue west, Calgary, and embrace practically the whole of the provinces of Alberta and Saskatchewan. The large extent of this area necessitates engineers being placed in charge of various subdistricts from the district office. For this reason the whole of the stream measurement work is divided into two divisions, namely, northern and southern, each of which is in charge of a division hydrometric engineer with headquarters at Calgary.

During the year such field investigations of water-power schemes as were called for were made under the direction of the district office by the hydrometric staff already located in the field. This is in accordance with the general principle that the hydrometric staff should form the basic organization and be drawn upon for special investigations.

CO-OPERATION

In accordance with the arrangement made between this branch and the Reclamation Service at the time of the transfer of hydrometric activities, in 1920, the closest co-operation has been maintained with the Reclamation Service which is dependent on this branch for stream flow data in connection with its duties under the Irrigation and Drainage Acts. The present office is adjacent to that of the Irrigation Division of the Reclamation Service and data required by that branch is as readily available as before the transfer of the hydrometric work to the Dominion Water Power Branch. In addition special studies of absorption losses in reservoirs and canal carriage losses have been made by this branch whenever requested by the Director of Reclamation. The annual investigation of snow and ground-water conditions requested by the Director of Reclamation in connection with flood warnings on the Bow river was made on the headwaters of this stream during early June and an additional survey of a similar nature inaugurated on the headwaters of the St. Mary river in co-operation with the Canadian Reclamation Service and the Water Resources Branch of the United States Geological Survey.

All hydrometric work in connection with the international problem of the division of the waters of the St. Mary and Milk rivers has been carried on by this branch under the direction of the Director of Reclamation, Canada's accredited officer in this connection. The fullest co-operation has been con-

tinued with the Montana Division of the United States Geological Survey and the United States Reclamation Service in the measurement of international waters on the Montana-Alberta and Saskatchewan portion of the boundary.

At all points on the irrigation projects operated by the Canadian Pacific Railway's Department of Natural Resources where measurement of diverted water is necessary, our engineers have co-operated with those of that company. At the request of the chief engineer of this organization an investigation of the canal carriage losses of its western section main canal was made in co-operation with the company's hydrometric staff.

At the request of the Director of the Meteorological Service inspections of meteorological stations throughout the two provinces were made during the course of the year. Reports on the condition of these stations were sent to the head office of the Meteorological Service at Toronto. The meteorological observer at Banff accompanied the district chief engineer and the assistant district chief engineer on the annual flood warning survey at the headwaters of the Bow river.

In co-operation with the universities of Alberta and Saskatchewan field demonstrations were given for the students. In addition lectures on the subjects of hydrometric and water-power engineering were given at each university.

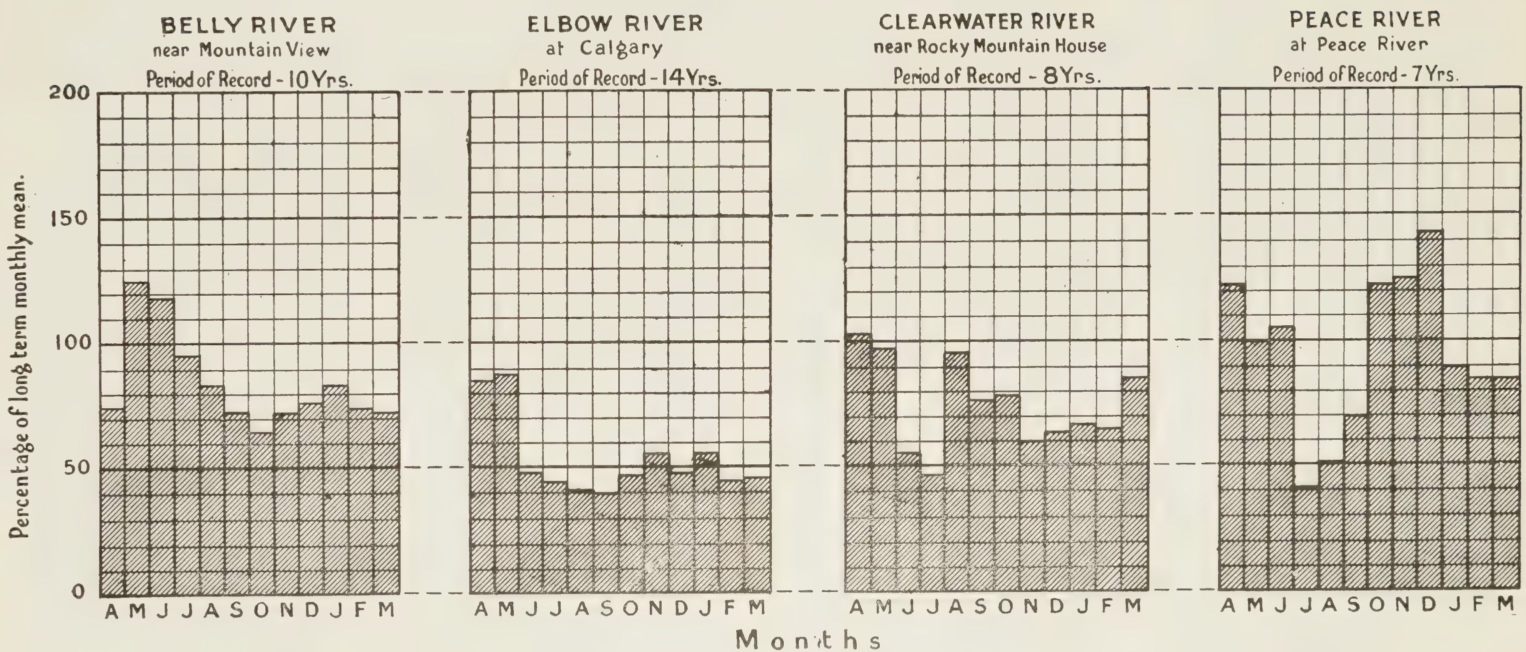
THE HYDROMETRIC SURVEY

During the year 365 gauging stations were maintained on streams, canals, ditches and lakes in the following main watersheds: Assiniboine, Athabaska, Battle creek, Belly, Bow, Frenchman, Little Bow, Lodge creek, Milk, North Saskatchewan, Oldman, Peace, Qu'Appelle, Red Deer, Rock creek, Ross creek, St. Mary, Saskatchewan, Sevenpersons creek, Slave, Souris, South Saskatchewan, Swiftcurrent creek and Waterton. Of the above 15 were maintained on streams and 2 on lakes throughout the year and 7 during open-water season only for power purposes. Eighteen stations on streams were maintained throughout the year and 61 on streams and 7 on lakes during open-water season for irrigation purposes. In addition 154 stations were maintained on canals and ditches during the irrigation season. For drainage purposes 4 stations were maintained on streams and one on a lake all year and 17 stations on streams and 18 on lakes during the open-water season and 3 on canals or ditches. For domestic water supply purposes 4 stations were maintained throughout the year on streams and 1 on a canal, and 3 were maintained during open-water only. Two stations were maintained for flood warning purposes for short periods of the year. In connection with problems arising between the United States and Canada 35 stations were maintained on international streams and canals. Stations were also maintained on 13 streams and lakes for statistical purposes.

PLATE 2

MEAN MONTHLY RUNOFF OF TYPICAL WATERSHEDS
IN
ALBERTA
FOR YEAR 1922-23

RUNOFF SHOWN AS PERCENTAGE OF LONG TERM MONTHLY MEAN



In many parts of Alberta and Saskatchewan the precipitation was higher than it had been during the past few years but in central and northern Alberta it was far below average. The resulting run-off followed the precipitation in general although in many areas the ground-water table, so depleted by a succession of dry years, has not been raised to any extent by the increased precipitation of last year. This is shown by the records of the Belly river near Mountain View where the run-off was 98 per cent of average while the Elbow at Calgary was only 53 per cent of average, the Clearwater near Rocky Mountain House 71 per cent of average and the Peace at Peace river only 84 per cent of average. The Battle river at Battleford, which drains a large portion of central Alberta and the central part of western Saskatchewan, shows the drought in that area even more than those previously mentioned, with a run-off of only 25 per cent of average.

In northern Saskatchewan the records of the Carrot river show that the run-off in this area was 71 per cent of the average for the past three years and for a long period record would be even closer to average. A heavy spring run-off in the central part of eastern Saskatchewan resulted in floods in the Qu'Appelle valley and this stream, at Lumsden, shows a run-off of 287 per cent of the average of the previous years of record and six and a half times the discharge of the year previous. In southwestern Saskatchewan the records of Battle creek near Tenmile show the run-off was 101 per cent of the average of the twelve previous years of record.

Precipitation records from typical stations compare with run-off records quite closely and for southwestern Alberta show 85 to 90 per cent of average, for central Alberta 80 per cent of average, and for northern Alberta from 76 to 52 per cent of average. In Saskatchewan records of precipitation in the northern part show about 90 per cent of average and for the southern part 106 per cent of average.

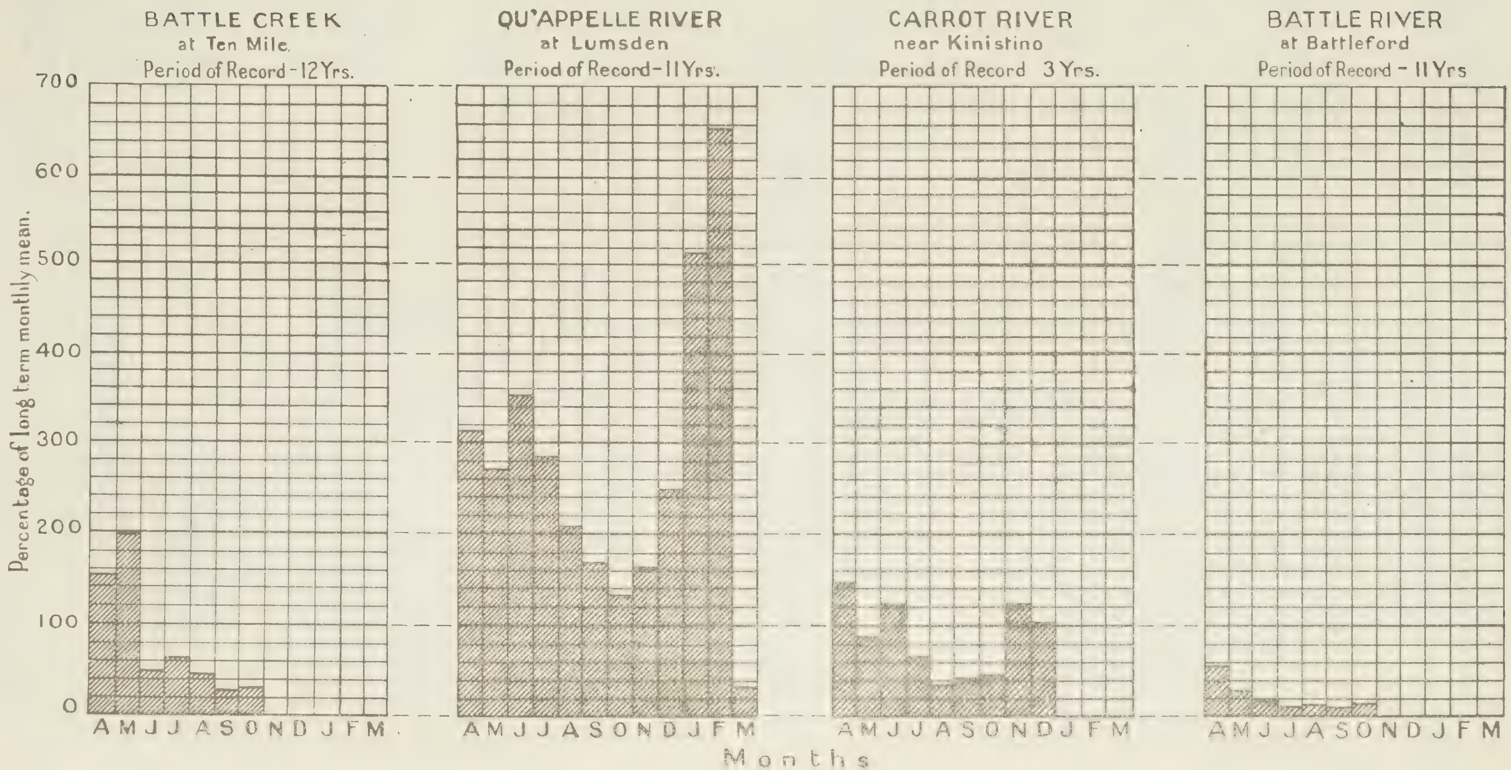
The only floods of note were those in the Assiniboine basin in Saskatchewan. As previously mentioned, the Qu'Appelle river had an extremely high run-off and reached a new maximum of 2,574 second-feet at Lumsden. The highest previous record was 2,413 second-feet in 1916 and the highest previous year was 1916-17, when the run-off was 94 per cent of that of the past year. Abnormally low flow conditions prevailed on the Elbow, Red Deer, North Saskatchewan, Athabaska, St. Mary and several other streams for short periods, but the principal main streams to establish new low year run-offs were the Elbow, where the past fiscal year was 86 per cent of the lowest previous fiscal year, that of 1919-20, and Battle river, where the run-off for the period April to October inclusive was 94 per cent of the lowest similar period, which occurred in 1919.

Graphs showing the run-off by months as percentage of the long term monthly mean have been prepared for streams in southern, central and northern Alberta and for northwestern, southwestern, northeastern and southeastern Saskatchewan. (See plates 2 and 3.)

This branch operates the only current-meter rating station in Canada. This station is located at Calgary, Alberta. Here the majority of the current-meters used in Canada are rated and much of the repair work in connection with these meters carried out. When a meter is received at this station it is rated and then, after being put in good repair, is rerated. Rating tables are then prepared for each rating and these returned with the meters to their owners. During the year the station was operated from May 11 to November 16, when 92 current-meters were rated, 116 sets of rating tables prepared, and 40 meters repaired. Of the above, 9 meters were rated for the Reclamation Service, 7 for the Water Rights Branch of British Columbia, 4 for the Canadian Pacific Railway Company, 1 for the Empire Engineering Company of Prince George, B.C., 2 for the Quebec Streams Commission, and the balance for the various offices of the

MEAN MONTHLY RUNOFF OF TYPICAL WATERSHEDS
IN
SASKATCHEWAN
FOR YEAR 1922-23

RUNOFF SHOWN AS PERCENTAGE OF LONG TERM MONTHLY MEAN



Dominion Water Power Branch as follows: Ontario, 7; British Columbia, 13; Maritime Provinces, 2; Manitoba, 11; Alberta and Saskatchewan, 34. In addition, 2 meters were rated under various conditions in connection with experimental work and tests, on which reports were prepared.

SPECIAL INVESTIGATIONS

In the spring of 1921 this branch was requested to take over from the Calgary Power Company the operation of lake Minnewanka storage during the filling season as it was considered that such action would be in the interests of the public. In 1922 the branch reassumed the responsibility for the filling of the reservoir on May 6 and although filling operations had to be suspended for a short period to comply with a request of the Dominion Parks Branch in connection with some construction work they had in hand, the lake had been brought up to the required level by the opening of the tourist season.

Application for permit to divert water from the Crowsnest river for the purpose of developing power at Crowsnest falls (sec. 28, tp. 7, rge. 8, W. of 5th meridian) was received from the Christian Community of Universal Brotherhood of Alberta, Limited, dated June 6, 1922. Attention was given to the water-power and irrigation phases of the project and the granting of an interim license recommended.

Acting on information that Mr. Gilles Forcier had undertaken a small water-power development on Cranberry creek (sec. 9, tp. 59, rge. 16, W. of 3rd meridian) an investigation of the site was made in October. The proposal is not considered feasible and a report was submitted to that effect.

An investigation of the condition of a dam at the outlet of Gull lake (tp. 40, rge. 1, W. of 5th meridian) was made. It was found that the dam had been constructed to create storage in connection with a power project, and had been subsequently destroyed and again rebuilt recently. A report was prepared which recommended that as the license to construct was granted under the Irrigation Act, and as the storage was of no further value for power purposes, the matter of the conditions resultant upon the reconstruction of the dam be referred to the Reclamation Service with a recommendation that the license be cancelled.

The office studies of the dependable outflow from Spray lakes storage under different conditions of regulation commenced in the previous year were continued and completed.

Further office studies of the effect of regulation of lake Minnewanka storage were made, including a study of the effect of daily regulation to synchronize the power output of Calgary Power Company's existing plants on the Bow river with the proposed Cascade river high level diversion scheme. This study was completed.

Office studies of the power possibilities of the Bow River basin and the effect on the regimen of the Bow river of operating storage reservoirs in the basin were undertaken but not completed.

At the request of the Director of Reclamation, the investigation of absorption losses in lake Newell reservoir was continued in co-operation with the hydrometric engineer of the Canadian Pacific Railway Company's eastern irrigation section and a report prepared.

An investigation and report was made on the carriage losses in the main canal of the Canada Land and Irrigation Company at the request of the Commissioner of Irrigation.

In co-operation with and at the request of the Department of Natural Resources, Canadian Pacific Railway Company, an investigation and report was made on carriage losses in the main canal of their western irrigation section.

Field investigations of flood conditions in the Qu'Appelle River basin in the spring of 1922 were made at Regina and Lumsden and a report on their cause and extent was submitted.

The annual flood prediction survey of the snow field at the headwaters of the Bow river was made in June. A survey of the snow fields at the headwaters of the St. Mary river was made in May and a reconnaissance of other areas in the St. Mary valley in August. Reports of these surveys were completed and submitted.

During the summer of 1922 the Reclamation Service carried on an extensive investigation on carriage losses in Battle creek in connection with the division of the waters of this stream as defined by the International Joint Commission. Engineers of the Dominion Water Power Branch assisted on this work in construction of the necessary structures, stream measurements, and advice in the field and by computations in the office.

The hydrometric records of the branch have been extensively drawn upon in connection with the design and construction of a number of important irrigation projects they have also formed the basis of a number of water supply developments. Many requests have also been received for data from Government departments both Federal and Provincial, railway and irrigation companies, municipalities, corporations, engineers and private citizens concerned with the subject of the supply, use or disposition of water.

DISTRICT OF MANITOBA

C. H. Attwood, District Chief Engineer.

During the fiscal year ending March 31, 1923, the regular stream measurement and power investigatory operations of the Dominion Water Power Branch in Manitoba and adjacent districts have been continued.

The scope of the work covered by this district organization comprises the power survey and storage investigatory work in Manitoba and the hydrometric work in the province of Manitoba and in that portion of western Ontario inclusive of and lying to the west of the Nipigon river.

ORGANIZATION

The local organization of the Dominion Water Power Branch, headquartered at 231 Chambers of Commerce, Winnipeg, was organized in 1912 and the work then instituted has been carried on and extended from time to time. The duties of the engineers and the hydrometric recorders consist of both field and office work, including surveys, investigations and the preparation of the data collected in report form, for submission to the head office.

CO-OPERATION

The organization works in co-operation with several departments of the Federal and Provincial Governments, particularly the Public Works Department and the Reclamation Service of the Federal Government, and the Power Commission and the Drainage Commission of Manitoba.

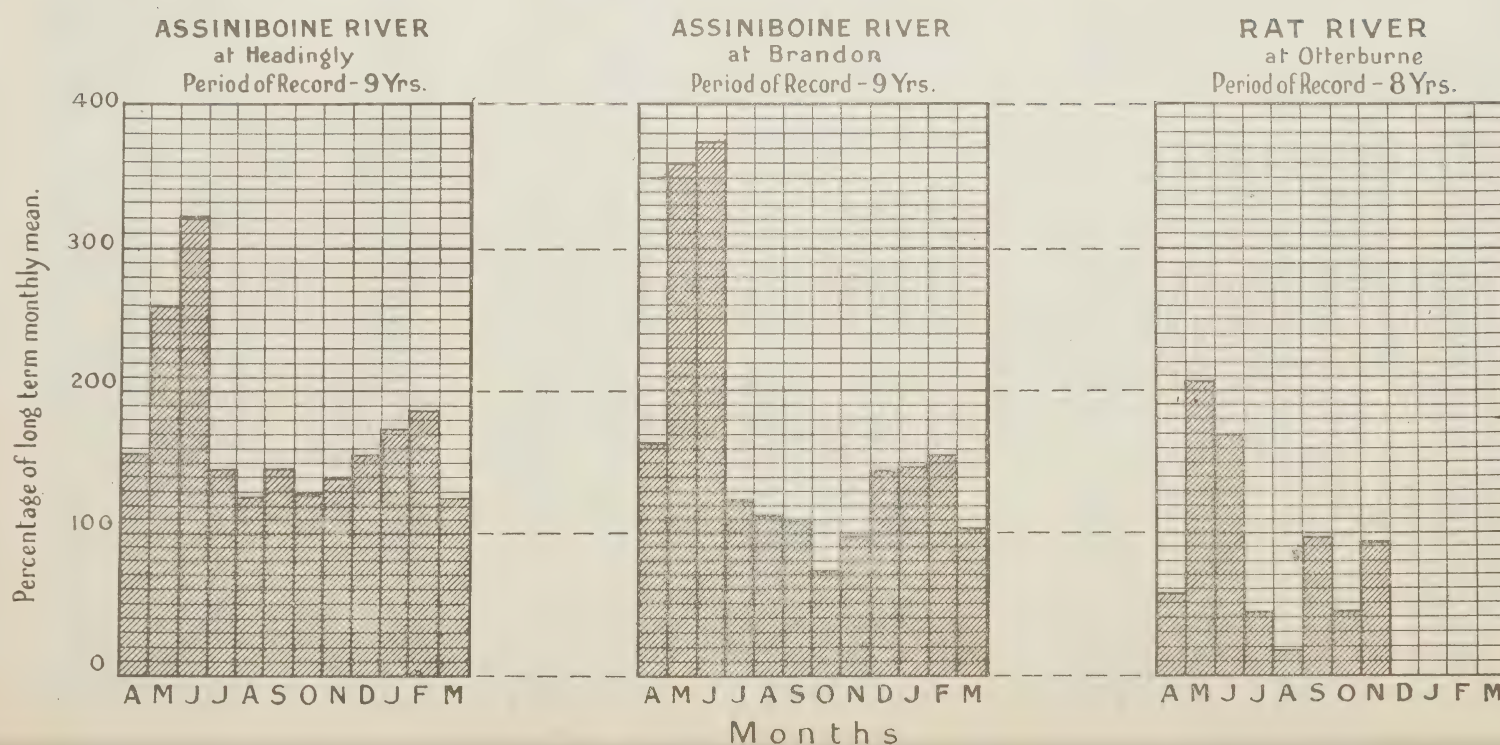
HYDROMETRIC SURVEY

During the year 112 gauging stations have been maintained on lakes, rivers and tributaries in the following main watersheds: Nelson river, lake Winnipeg, Winnipeg river, lake of the Woods, Rainy lake, English, Red, Assiniboine, Dauphin and Saskatchewan rivers.

Of the above stations, 49 were maintained throughout the year and 6 during open-water season only, for power and storage purposes. For drainage and reclamation purposes, 6 stations were maintained all year and 29 during open-water. Three stations were maintained during open-water only for water supply

MEAN MONTHLY RUNOFF OF TYPICAL WATERSHEDS
IN
MANITOBA
FOR YEAR 1922-23

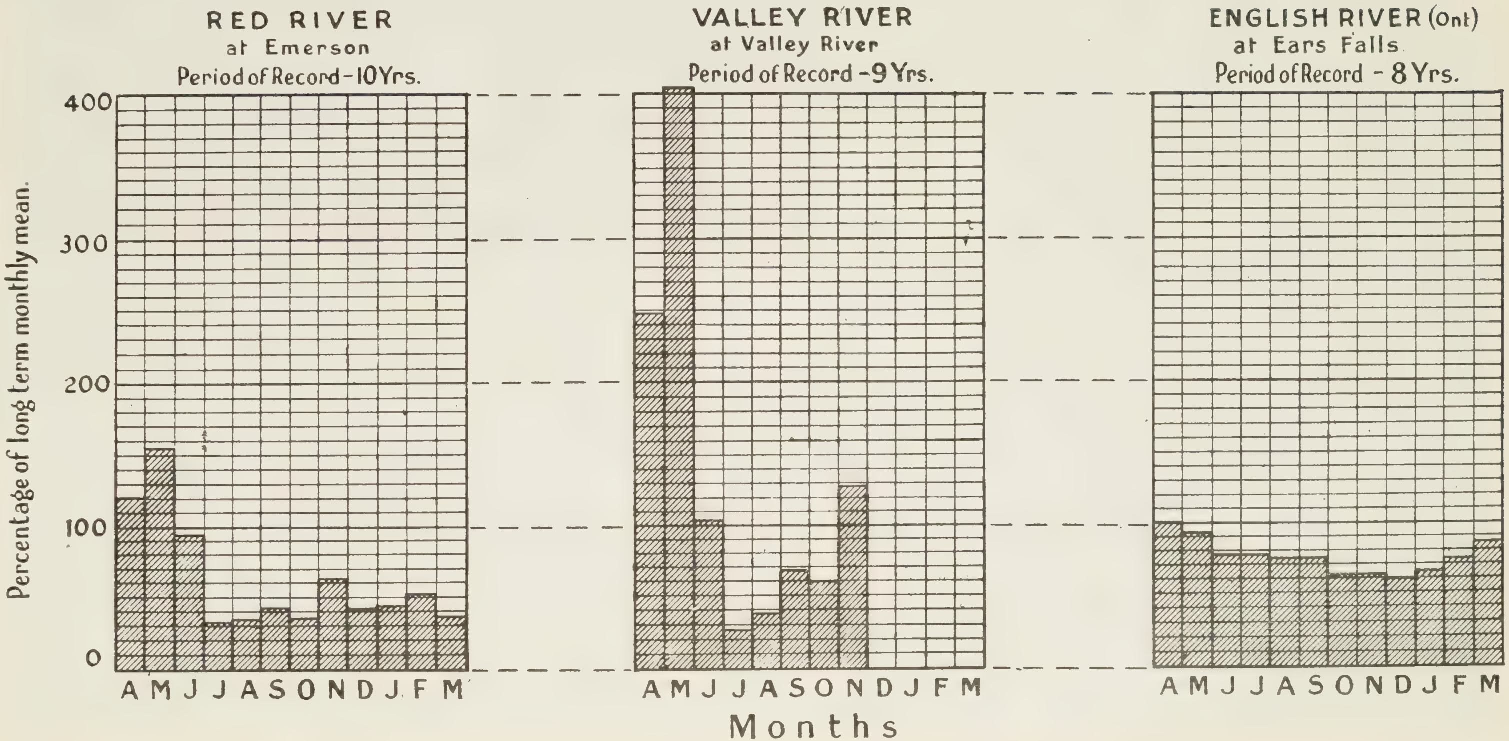
RUNOFF SHOWN AS PERCENTAGE OF LONG TERM MONTHLY MEAN



MEAN MONTHLY RUNOFF OF TYPICAL WATERSHEDS IN MANITOBA

FOR YEAR 1922-23

RUNOFF SHOWN AS PERCENTAGE OF LONG TERM MONTHLY MEAN



problems, and for statistical purposes 4 all-year stations. On International streams in connection with problems arising between the United States and Canada 15 stations were maintained all year and 5 for open-water only. Ten meteorological stations were maintained continuously. In the above classification it will be noted that some of the stations are maintained for more than one purpose.

In the following review of the precipitation and run-off conditions during the year ending March 31, 1923, in Manitoba and that portion of Ontario west of the Nipigon river, certain rivers on which records have been obtained have been chosen as representative of the different districts. As no stations are maintained in that portion of Manitoba north of the Saskatchewan river, this area is not included in this review.

Taking the Red river at Emerson as typical of that portion of Manitoba south of, and not draining into, the Assiniboine river, the run-off for the past year was low, being 89 per cent of the mean of previous years. The maximum monthly run-off of the Red river generally occurs during the period April-July. The maximum run-off in 1922 which amounted to 0·367 second-foot per square mile, occurred in April, was 44 per cent of the highest monthly maximum recorded in April, 1916. The minimum monthly run-off occurred in January, 1923, and was 0·009 second-foot per square mile. This is 138 per cent of the lowest recorded, which occurred in February, 1918. The low run-off during the latter part of the year, as shown on the accompanying graphs, is partially explained by the fact that freeze-up was unusually late. This, together with the numerous drainage ditches in North Dakota and Minnesota, favoured the run-off of precipitation together with a lowering of the ground water. The precipitation for the first four months of the year was 9·95 inches, being practically the same as the mean for this period. The snowfall to the end of the year, however, was 141 per cent of the normal.

The run-off of the Assiniboine river at Headingley, which drains the prairie lands of western Manitoba, was 207 per cent of the mean of previous years. The maximum monthly run-off in 1922 was 0·244 second-foot per square mile and occurred in May, and was 199 per cent of the highest monthly maximum recorded, which occurred in May, 1913. The minimum monthly run-off occurred in March, 1923, being 0·006 second-foot per square mile and was 340 per cent of that of January, 1918, the lowest recorded. At Brandon the run-off of the Assiniboine was high, being for the year 226 per cent of the mean. The maximum monthly run-off occurred in May, and was 0·443 second-foot per square mile. This was 150 per cent of the highest recorded monthly maximum, which occurred in May, 1913. The minimum monthly run-off occurred in March, 1923, being 0·006 second-foot per square mile, and was 355 per cent of the lowest recorded monthly minimum, which occurred in February, 1915. Though flood conditions occurred on the Assiniboine river during the latter part of April and during May, the precipitation for the first four months of the year was not high, being 103 per cent of the normal. The high run-off in April and May was due to the thorough saturation of the ground the previous fall, together with a heavy fall of snow in April, followed by warm weather and rain. This precipitation practically all appeared as run-off, causing flood conditions in many reaches of the river during April and May. Over the Assiniboine watershed the snowfall during the past winter was 157 per cent of the normal..

In the northern part of Manitoba the run-off of the Valley river at Valley River for the year was 200 per cent of the mean. The maximum monthly run-off was 2·286 second-feet per square mile and occurred in May. This was 147 per cent of the previous recorded monthly maximum of April, 1913. The minimum monthly run-off occurred in August, being 0·029 second-foot per square mile. For the first four months the precipitation was 86 per cent of the normal.

IMPORTANT NOTICE

PLEASE NOTIFY THE DIRECTOR OF WATER POWER, MOTOR BUILDING, OTTAWA, PROMPTLY OF ANY CHANGE IN YOUR ADDRESS

The number of these reports available for distribution is limited. If for any reason you wish the sending of them to be discontinued, you will oblige the Director by notifying him accordingly.

In Ontario the run-off of the English river at Ear falls was only 74 per cent of the yearly mean. The maximum run-off occurred in July and was 0·631 second-foot per square mile. This was 37 per cent of the highest recorded monthly maximum which occurred in July, 1916. The minimum monthly run-off of 0·322 second-foot per square mile occurred in March and was 111 per cent of the recorded minimum of March, 1921.

Taking the depletion period as from April 1 to September 30, and the storage period as from October 1 to March 31,, the precipitation and run-off during these periods on the watersheds of the typical rivers as described above are as follows:—

During the depletion period the mean run-off for the Red river at Emerson was 0·129 second-foot per square mile, or 99 per cent of the mean, and only 35 per cent of the run-off in 1916 when flood conditions occurred. The lowest recorded mean run-off for the same period occurred in 1918, and was 33 per cent of the mean. The average run-off during the storage period was 0·013 second-foot per square mile and is the lowest recorded. The run-off for 1922-23 is only 25 per cent of that of 1916-17, which is the highest on record. The precipitation for this period was 141 per cent of the normal.

The Assiniboine river at Headingley for the depletion period had the highest mean run-off recorded, being 0·101 second-foot per square mile and 217 per cent of the mean. The lowest recorded mean run-off for the same period occurred in 1915, and was 25 per cent of the mean. During the storage period the mean run-off was 0·011 second-foot per square mile, or 144 per cent of the mean. The highest recorded run-off occurred in 1921-22 and was 255 per cent of the mean, the lowest occurring in 1914-15, when the run-off was 52 per cent of the mean. At Brandon the mean run-off during the depletion period was 0·156 second-foot per square mile, or 249 per cent of the mean. In 1915, which was the lowest for the period of record, the run-off was 24 per cent of the mean. The run-off for the storage period was 0·012 second-foot per square mile, which is 103 per cent of the mean. The highest recorded run-off was in 1913-14, it being 308 per cent of the mean, and the lowest in 1915-16, was 30 per cent of the mean.

The run-off of the Valley river for the depletion period was 0·686 second-foot per square mile, which was 209 per cent of the mean. This is the highest for the period of record, the lowest occurring in 1915, when the run-off was 16 per cent of the mean.

On the English river at Ear falls the run-off during the depletion period was 0·523 second-foot per square mile, or 80 per cent of the mean. The highest recorded run-off, which occurred in 1916, was 178 per cent of the mean. The lowest occurred in 1917, and was 65 per cent of the mean. The run-off during the storage period was 0·343 second-foot per square mile, or 67 per cent of the mean, which is the lowest for the period of record. The highest recorded run-off occurred in 1921-22 and was 115 per cent of the mean. For the depletion period the precipitation was 18·71 inches, while that for the storage period was 6·51 inches.

In the province of Manitoba and the territory covered by this report a late open fall was followed by a winter during which there was some 50 inches of snowfall. With the exception of three or four days of mild weather at the beginning of March, no thaws occurred during the winter, with the result that most of the snowfall is still lying on the ground. With all this snow still lying on the ground and with no rise in the rivers to date, there is every likelihood of a large run-off during April. Whether or not these conditions will result in floods, depends to a large extent on the weather conditions during the next three or four weeks. A sudden change to high temperatures will, without doubt, result in flood conditions on many rivers and streams in this territory.

SPECIAL INVESTIGATIONS

The following investigations were carried out during the year:—

Peterson Creek.

Following an application for the right to develop a small water-power on Peterson creek in the S.W. $\frac{1}{4}$, Sec. 7, Tp. 17, Rge. 14, E.P.M., to operate a small saw and grist mill, an investigation was made of the site in October by an engineer from this office.

At the power site the creek flows over rocky ridges in a series of cascades with a total drop of 21 feet. The proposed layout for development consists of a masonry and concrete dam extending across the stream at the crest of the water falls with a wooden flume about 55 feet in length leading to a timber bulkhead and wheel pit. When investigated it was found that the applicant had built the masonry and concrete dam and had also purchased a second-hand turbine. While the amount of power available is small, it is probably quite sufficient to meet the requirements of the applicant, particularly during spring and fall months, and it is claimed that the development of this site will greatly assist and benefit the local settlers in that community.

Assiniboine River Flood.

Last spring, following break-up, a flood of unusual proportions and duration occurred on the Assiniboine river. Though no loss of life occurred, thousands of acres of seeded land were flooded, the main highways at a number of points destroyed, and a large number of houses damaged, particularly in the city of Brandon.

The indirect cause of the flood was the exceptionally heavy rains of last September, October and November, which thoroughly saturated the land and filled the lakes and sloughs just prior to freeze-up. The direct cause of the flood was the heavy precipitation in the form of snow and rain in April, falling on an already saturated ground surface. The spring break-up, which occurred during the first week of April, was followed by two heavy snow storms on April 9, and 18. These storms were followed by heavy rains and high temperatures. The land being still water soaked from the rains of last fall and the spring thaw, could absorb practically none of this heavy precipitation, and in consequence the water quickly found its way into the main channels of the Assiniboine river and its upper tributaries, causing excessive high-water and floods. Heavy rains on the upper watershed during the first half of the month of May were responsible to a large extent for the continued high stage or the long duration of the flood.

As an illustration of the rapidity of the rise, the Assiniboine river at Millwood rose 11 feet between April 19, and 26, and maintained this high stage for nearly a week before it began to recede. The river discharge at this point during the high stage was at a rate of 18,000 cubic feet per second.

At Brandon, which by river is some 235 miles below Millwood, the river started to rise on April 29, and reached its peak on May 6, with a total rise of $7\frac{1}{2}$ feet, and a discharge of 22,200 cubic feet per second. That the rise at Brandon was not so great as that at Millwood, even though the flow was larger, was due to the increased capacity of the river channel and also to the flooding of the river valley, which varies from one-half mile to two miles in width between these points.

At Portage la Prairie, which by river is 162 miles below Brandon, the peak was reached on May 10, with a total rise of $5\frac{1}{2}$ feet, and at Headingley the peak was reached on May 19, the rise at this point being slightly over 5 feet.

Due to the flooding of lands in the river valley, the peak of the flood was 14 days in travelling from Millwood to Portage la Prairie, a distance by river of 400 miles, or at a rate of one and one-sixth miles per hour. The mean velocity

of the river in the main channel, however, was two and three-quarter miles per hour, with a surface velocity of about four and one-half miles per hour.

The gradient, and therefore the velocity of the Assiniboine and its tributaries is not very great, so that when they are called upon to dispose of unusually large quantities of water they rise to very high levels and overflow the banks at low points. The Assiniboine river flooded the low-lying lands in the river valley practically from Kamsack to below Brandon. Between Millwood and Brandon, the whole river valley, varying from one-half mile to two miles in width, was flooded. At Brandon nearly all the houses on the river flats were flooded up to floor level. In the Brandon district about 15,000 to 20,000 acres of seeded land, or land ready for seeding, were flooded, while further upstream flooding occurred over some 10,000 acres of seeded land.

Between Portage la Prairie and Winnipeg the river overflowed its banks on the north side at High Bluff and Poplar Point, and flooded the lands north to the C.P.R. main line, and in some cases beyond, and extended easterly to Pigeon lake, flooding from 25,000 to 30,000 acres of land and destroyed the main Winnipeg to Portage la Prairie highway in many places. On the south side of the river, east of Poplar Point, only the strenuous and continuous efforts of the farmers in building and maintaining dykes prevented the floods from reaching the lower lying lands to the south.

Fortunately for Winnipeg the Red river had fallen 5 feet from the spring peak before the Assiniboine floodwaters reached the city, and although a sudden rise of 5 feet occurred on the Red river about May 16, the river level was still 8 feet below the point at which it overflowed in 1916.

Flooding to a smaller extent also occurred along the Qu'Appelle and Shell rivers.

Lake of the Woods.

In connection with the provision of increased outflow capacity from lake of the Woods and the provision of adequate control works as recommended by the International Joint Commission, certain detail surveys were at the request of Lake of the Woods Control Board made in December, at the lake outlets. Plans of the surveys, together with interrelated estimates and computations, were prepared and submitted to the board.

Boundary Waters tributary to Rainy Lake.

Arising from proposals submitted to the Dominion Government for the development of storage reservoirs in the boundary waters above Rainy lake, arrangements were made by the Lake of the Woods Control Board whereby an officer of this organization made two special trips through the watershed during the summer followed by two trips in winter to secure measurements of flow of the major rivers and tributaries.

Winnipeg River Records.

A special office investigation has been made of the records of water levels at the various gauging points on the Winnipeg river. At many gauging stations the records are of limited period while at certain others the gauge relationship has been affected at times by ice or change in control sections. By a systematic correlation of the various gauges, the results of the work have shown that it will be possible to extend those records of short period and to deduce a continuous record of river regimen under the various conditions encountered.

Winnipeg and English River Precise Levels.

In anticipation of arrangements made with the Geodetic Survey of Canada by the Dominion Water Power Branch and the Lake of the Woods Control Board for a line of precise levels along the Winnipeg river from Fort Alexander to Kenora and along the English river from its junction with the Winnipeg to

lac Seul, a series of permanent bench-marks were installed at all power-houses, power-sites and governing points on the two rivers. The type of bench-mark installed was the standard three-inch bronze tablet of the Geodetic Survey, and in each instance the tablet was leaded in bed rock and suitably referenced for future location. Between December and February the Geodetic Survey carried through the line of levels, tying in all benches above referred to.

As an indication of the value of stream flow records it can be stated that the construction of the various power developments in this district during the past year, costing between ten and twelve millions of dollars, depended essentially on the records of the department. During the year many requests for stream flow and lake records have been received from officers of the Manitoba and Ontario Governments, the Canadian National Railways and from numerous power, pulp and paper, and construction companies, and consulting engineers.

CONSTRUCTION

Rapid progress has been made in the construction of the Great Falls Development of the Manitoba Power Company. With the construction of the power-house coffer dam and the assembly of construction plant, tracks, yards, camp buildings, etc., practically completed during the previous years, everything was in readiness for an active start on construction of the power-plant in the spring of 1922. During the year rapid progress was made on construction. By July the power-house excavation was completed to grade. The placing of forms and concreting was started in May and the foundations of the power-house and head works were completed in November. The power-house superstructure covering the first three units was completed in December. Concurrent with the construction of the power-house was carried on the construction of the dam and wingwalls and excavation of Whitemud Falls channel. By December the concrete section of the dam across Island No. 2 was completed with the exception of the sluice gates and the temporary sluices. To date the rock-fill portion of the dam is completed to elevation 790·0 feet, and good progress made on the rock-cut at Whitemud falls, where, in addition to the construction of the cofferdam, some 100,000 cubic yards of rock have been excavated. In January the first 28,000-horsepower unit, operating under a temporary head of 24 feet, was delivering power to the transmission lines and has since been in continuous service. Immediately following this installation of unit No. 2 was started and this unit is now installed. This production of power is one year ahead of the original program and is the result of a remarkable construction achievement extending from March to the end of the year, as prior to March only preparatory work had been done.

DISTRICT OF ONTARIO

S. S. Scovil, District Chief Engineer.

During the fiscal year ending March 31, 1923, the regular stream measurement and power investigatory operations of the Dominion Water Power Branch in the province of Ontario have been continued consistent with the terms of the co-operative agreement under date of October 1, 1919, between the Department of the Interior and the Hydro-Electric Power Commission of Ontario.

ORGANIZATION

The work in Ontario has been continued under the direction of the district chief engineer's office at Ottawa with one sub-office at North Bay as a centre for field operations. Similar to the previous year the hydrometric investigations in the province west of and including the Nipigon river were carried on under the direction of the district office at Winnipeg.

CO-OPERATION

In pursuing the field and office investigations the closest co-operation has been maintained with the officers of the Hydro-Electric Power Commission. Valuable assistance has been given the engineers of the district by various persons and corporations interested in the securing of hydrological data. In particular, reference should be made to the co-operation carried on with the following companies: The Abitibi Power and Paper Company, the Algoma Power Company, the Algoma Steel Corporation, the International Nickel Company of Canada Limited, the Kaministiquia Power Company, the Mattagami Pulp and Paper Company, the Mississippi River Improvement Company, the Pigeon River Lumber Company, the Spanish River Pulp and Paper Company, the Spruce Falls Company, Messrs. Sutcliffe and Neelands, and Messrs. Kerry and Chace.

HYDROMETRIC SURVEY

During the year 58 gauging stations have been maintained on rivers and tributaries in the following main watersheds: Abitibi, Aux Sable, Beaver, Blanche, Bonnechere, Credit, Dog, Grand, Groundhog, Kapuskasing, Madawaska, Maganatawan, Magpie, Mattagami, Mattawan, Michipicoten, Missinaibi, Mississagi, Mississippi, Moira, Montreal (A.C. Ry.), Montreal, Elk Lake, Muskoka, Niagara, Napanee, Nipigon, Petawawa, Saugeen, South, Spanish, Sturgeon, Sydenham, Tay, Thames, Wanapitei and York.

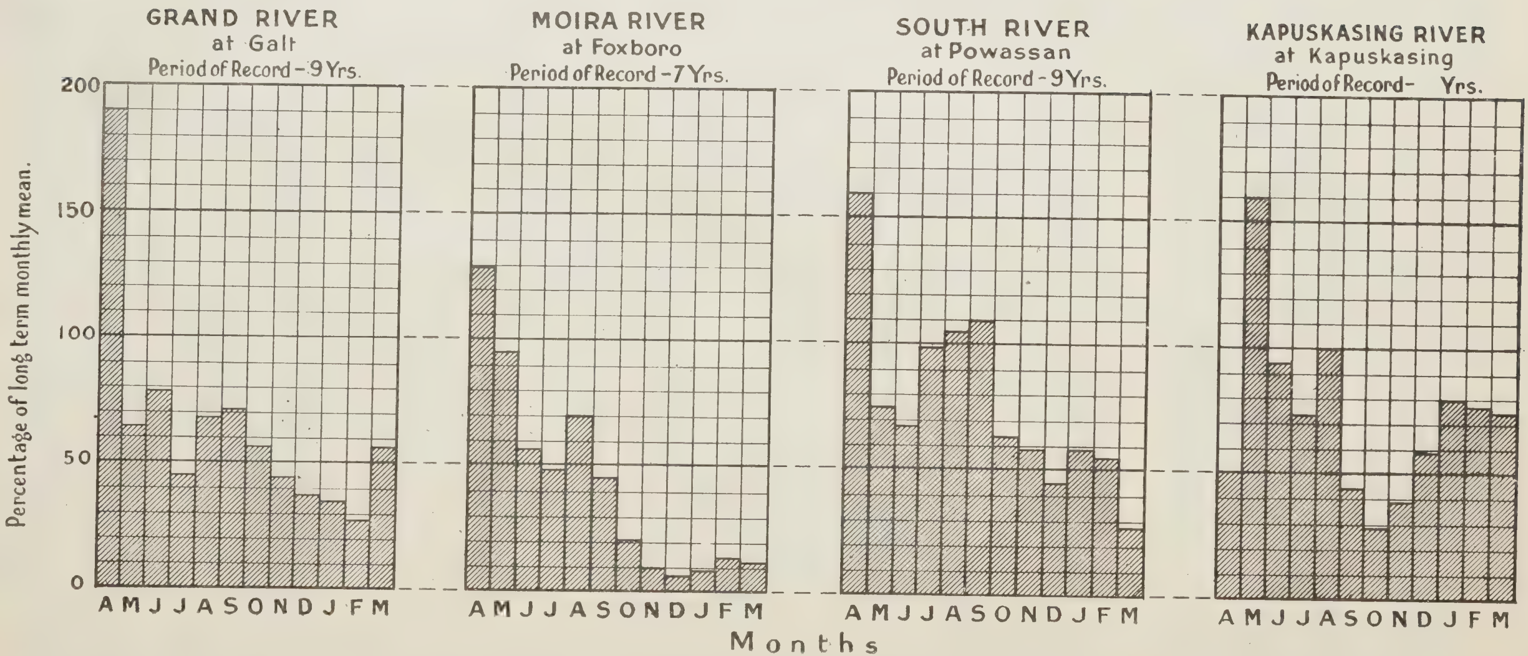
Of the above 44 were maintained throughout the year for power and storage purposes. Eleven stations were maintained continuously for flood and drainage purposes, one on an international river in connection with problems arising between United States and Canada together with one station for domestic water supply during the open season.

Run-off conditions encountered during the past year throughout the province were for the most part below normal. This is illustrated on plate 6, showing the monthly run-off as a percentage of the average flow over a number of years. The run-off of the Grand river at Galt is typical of the southwestern district, the Moira river at Foxboro of the eastern district, the South river at Powassan of the central or North Bay district and the Kapuskasing river of the northern district.

Records are available at Galt on the Grand river covering a period of nine years, during which period the run-off averaged 0.794 second-foot per square mile. An analysis of the records during the past year indicates that the mean flow for the year, 0.640 second-foot per square mile was only 80 per cent of the nine-year average. During the year April was the only month which showed a run-off above the average. The mean for this month, which reached a new high level of 3.942 second-feet per square mile, was 190 per cent of the nine-year mean. For the balance of the year the run-off was wholly subnormal, ranging from June, when the flow, 0.356 second-foot per square mile, was 79 per cent of the nine-year period, to February, when the flow was 0.134 second-foot per square mile, or only 26 per cent of the mean for the period.

Records are available of the Moira river at Foxboro for the past seven years, during which period the average run-off was 0·973 second-foot per square mile. The records of the past year indicate that the mean flow for the year, 0.694 second-foot per square mile, was only 72 per cent of the mean run-off for the seven-year period. During the year April was the only month above normal. The mean of 5·318 second-feet per square mile was 128 per cent of the seven-year average. For the balance of the year the flow was wholly below normal, ranging from May, when the flow, 1.667 second-feet per square mile, was 95 per cent of the seven-year mean, to December, when the flow was 0.035 second-foot per square mile, or only 6 per cent of the mean for the period. Although the mean run-off for the year was greater than the preceding one, new low means were recorded during the months October to March inclusive.

MEAN MONTHLY RUNOFF OF TYPICAL WATERSHEDS
IN
ONTARIO
FOR YEAR 1922-23
RUNOFF SHOWN AS PERCENTAGE OF LONG TERM MONTHLY MEAN



The records of the South river at Powassan cover a period of nine years. During this period the average run-off was 1.405 second-feet per square mile. The mean flow for the year, 1.282 second-feet per square mile, was 91 per cent of the average over the nine years. During the year only three months were above normal, April reaching a new high mean of 7·619 second-feet per square mile, or 160 per cent of the average for the nine-year period, with August and September slightly above the mean. For the balance of the year the flow was below normal, ranging from July with run-off 0·837 second-foot per square mile, or 98 per cent of the nine-year average, to March with flow of 0.510 second-foot per square mile, or 27 per cent of the mean.

The records of the Kapuskasing river at Kapuskasing cover only a period of five years. During this period the average flow was 0.840 second-foot per square mile. The mean flow for the year, 816 second-feet per square mile, was 97 per cent of the average over the five-year period. During the year, March was the only month above the normal, reaching a new high mean of 5.667 second-feet per square mile, or 159 per cent of the average for the nine-year period. The balance of the year was subnormal, ranging from August with flow of 0·319 second-foot per square mile, or 99 per cent of the five-year average, to October with flow of 0·170 second-foot per square mile, or 28 per cent of the mean for the period.

Although no extensive power surveys were made during the year, the systematic analysis of the developed and undeveloped water-power and storage resources of the province was continued.

NIAGARA RIVER INVESTIGATION

Office and field investigation of the problems relating to hydrology of the Niagara river were continued throughout the year. The determination of the discharge relation of the Niagara river from measurements made throughout the open-water season was completed and in addition to the compilation of pertinent records of water levels and diversions, the study of the relationship of the various gauging points and of the effect of diversions was continued.

In addition to a steady demand for the published records a large number of requests were received for water supply data in advance of publication; these were received from departments of the Provincial Government, corporations, engineers and private individuals for the solution of whose various problems this information was essential.

CONSTRUCTION

Although the work of the Dominion Water Power Branch in Ontario is confined to basic hydrometric investigations the important relationship these investigations bear to water-power development warrants the inclusion of a brief review of activities during the past year in water-power construction throughout the province.

The most important work carried out by the Hydro-Electric Power Commission has been the *Queenston-Chippawa* development. Of the five 55,000-horsepower units of the initial project the third and fourth have been completed and placed in operation during the year. The *Ranney Falls* development of 10,000 horse-power was placed in operation during August. Owing to the great demand for power the commission have carried out field investigations on the Trent at dams 8 and 9, also at Bingham chute on the South river and at Port Severn on the Severn river with a view to constructing additional power plants.

Considerable development has been undertaken by private interests. The reconstruction of the Canadian General Electric Company's plant on the Otanobee river by the addition of a 1,300-horsepower unit has been completed,

also the 200-horsepower plant on the Little Thessalon river by the town of Thessalon. The extension to the Kenora Municipal plant of 4,800 horse-power has been installed and is in operation. The new developments under construction include the 8,000-horsepower development (of the Lower Sturgeon Power Company) at Sturgeon falls on the Mattagami river, the 2,150-horsepower development of the Great Northern Power Company on the Montreal river at Indian chute, the 2,500-horsepower development of Spruce Falls Company on the Kapuskasing river at Kapuskasing and the 1,400-horsepower development of the Dryden Paper Company on the Wabigoon river at Wainwright.

DISTRICT OF QUEBEC

L. G. Denis, District Chief Engineer

Following a co-operative agreement between the Quebec Streams Commission and the Dominion Water Power Branch, basic investigatory work by the latter organization was extended to the province of Quebec during the fiscal year ending March 31, 1923. The agreement, which became effective on October 1, 1922, provided among other items for the taking over in co-operation of the various hydrometric stations which had been established and maintained by the Quebec Streams Commission throughout the province.

ORGANIZATION

To satisfactorily carry out the terms of the agreement with the Quebec Streams Commission a district office was opened in Montreal and the various phases of the Quebec work are carried on from this centre.

CO-OPERATION

In addition to the close co-operation with the Quebec Streams Commission for the work in Quebec province co-operative arrangements with private corporations such as the Shawinigan Water and Power Company, Laurentide Power Company, Brown Corporation, Quebec Development Company, Chicoutimi Pulp Company and Price Brothers' had been carried on by the Quebec Streams Commission and have been continued.

HYDROMETRIC SURVEY

During the past year there were 38 regular hydrometric stations maintained under co-operative agreement with the Quebec Streams Commission in the following districts of the province—Eastern Townships, lower St. Lawrence, lower Ottawa basin. One of these stations is not visited in winter while of the others, 3 are at outlets of storage reservoirs and 4 have been established mainly for flood observations. In addition there are 6 stations where gauge heights only are recorded. Fairly normal run-offs were noted in the Quebec rivers during the fall of 1922. The early portion of the winter of 1922-23 was marked with snowfall much below the average and accompanied by low temperatures with the consequent formation of heavy ice on rivers. The almost complete absence of the usual winter thaws also contributed to reduce the stream flow, resulting generally in the lowest discharges on record or previously remembered. As a result of this a number of special requests were received and satisfied in connection with meterings at points of particular interest for pending power developments to secure records during this period of unusually low flow. Heavy snowfalls occurred later on in the winter, and these more than compensated for the previous light fall, but the prevalent low temperatures persisting till the beginning of April continued to restrict stream flow.

SPECIAL INVESTIGATIONS

Special efforts have been made to secure all available data either published or otherwise accessible in connection with both undeveloped and developed water-power on the rivers of Quebec province. This is being arranged and classified and extensively used in satisfying specific requests for information of this nature and also in connection with the systematic preparation of summaries and other information for the Water Resources Inventory. The latter included office investigation and work on the synopses of water-power data for the basins of the Assomption, Maskinonge, Bayonne, Yamachiche, du Loup (Maskinonge Co), Ste. Anne de la Perade, Portneuf (Portneuf Co), Jacques Cartier, Chicoutimi, Shipshaw, Escoumains, Portneuf (lower St. Lawrence), Sault au Mouton, Sault au Cochon, Laval and Bersimis rivers.

CONSTRUCTION

Apart from the work carried on by the Dominion Water Power Branch in the province of Quebec it is of interest to briefly record some of the large water-power undertakings and allied activities of the past year.

The Quebec Streams Commission in continuing its highly beneficial policy of constructing storage reservoirs on various rivers, completed the thirty million cubic feet Savanne reservoir on the St. Anne de Beaupre river and commenced the construction of the thirteen billion cubic feet Kenogami reservoir on the Chicoutimi river. The anticipated results from the Gouin reservoir on the St. Maurice river have been definitely surpassed and as a consequence the two large hydro-electric plants on the river have added 89,000 horse-power to their capacities during the past year. Work was also started on the construction of a new hydro-electric development of 175,000 horse-power ultimate capacity at Gres falls on the St. Maurice river.

The largest project to be commenced was that of the Quebec Development Company at the Grand Discharge of the Saguenay river. This plant is to have an initial installation of 200,000 horse-power and an ultimate capacity of 350,000 horse-power. Among other projects commenced may be mentioned one by Price Brothers' Limited at Chicoutimi of 10,000 horse-power and a 3,700-horsepower development on the Metis river for the Lower St. Lawrence Power Company.

Projects on which construction is expected to start in the near future include a 30,000 horse-power hydro-electric plant for the Southern Canada Power Company at Hemming falls on the St. Francois river, a 29,000-horse-power plant for the Ottawa and Hull Power and Manufacturing Company, on the Ottawa river near Bryson, a hydro-electric plant of 100,000 horse-power ultimate capacity for the Hull Electric Company at Paugan falls on the Gatineau river and a 45,000-horsepower plant for the Back River Power Company, on des Prairies river.

DISTRICT OF THE MARITIME PROVINCES

K. H. Smith, District Chief Engineer.

During the fiscal year ending March 31, 1922, the operations of the Dominion Water Power Branch in Nova Scotia, New Brunswick and Prince Edward Island, comprising stream measurement and power investigatory work were continued in accordance with the co-operative agreement of July 1, 1919, between the Department of the Interior and the Governments of the three Maritime provinces.

ORGANIZATION

The work may be divided into two main divisions, hydrometric and power investigatory. The hydrometric portion consists of the field and office operations necessary for securing the basic statistical run-off data upon which all studies of water supply and power are based. The power investigatory work comprises investigations of all important power rivers and sites with regard to available heads, storage, water supply, power, general characteristics and market. It also entails special power investigations and reports made at the request of or in co-operation with provincial authorities, municipalities, corporations and individuals in regard to specific projects.

CO-OPERATION

Close co-operation is maintained between the district office and the Provincial Governments. Dominion Water Power Branch officials endeavour to meet every reasonable request for information and assistance as promptly as possible, and their services are frequently in demand both in the office and in the field. Considerable co-operative work was performed for the Nova Scotia Power Commission in connection with the East River, Sheet Harbour development and the Barrington, Bear River and Tusket projects.

HYDROMETRIC SURVEY

During the year 35 gauging stations were maintained—21 in Nova Scotia, 10 in New Brunswick and 4 in Prince Edward Island. Of the 18 rivers gauged in Nova Scotia 9 are important power streams and the others are representative streams from which records are obtained for statistical purposes. The 10 rivers in New Brunswick are with the exception of the Kennebecasis, important power streams. In Prince Edward Island there are no large power sites and the 4 gauging stations maintained are valuable only for statistical purposes in estimates of water supply for the numerous small sites that do occur. Owing to the large number of small mills operated on the island, the streams suitable for securing records from are few, and one station has recently been discontinued, leaving 3 representative stations only.

All stream flow records for the two-year period from September 30, 1920, to September 30, 1922, were computed and prepared for publication.

The outstanding feature of the run-off year was the abnormally high run-off in the summer months. In Nova Scotia heavy rains occurred in June, which caused mean flows for the month of 200 per cent of normal. August and September were also higher than usual, as the attached graphs depict. In New Brunswick, June, July and August were also about 200 per cent of normal with the exception of the south coast streams, such as Lepreau and Magaguadavic, where the floods occurred in August. Another very noticeable feature was the low run-off for the month of March which was experienced on all streams in the district. This was due to the exceptionally severe and long winter. The spring break-up, which usually occurs early in March in Nova Scotia and towards the end of March in New Brunswick, has not yet occurred at the date of writing. As a consequence the March run-off was from 40 to 60 per cent of normal in Nova Scotia and about 30 per cent in New Brunswick.

SPECIAL INVESTIGATIONS

In the regular routine power investigatory work a power and storage survey of the Ingraham river was completed. This stream is some twenty miles from Halifax and is adjacent to the Indian river upon which the development of the Nova Scotia Power Commission is at present supplying Halifax. It may, therefore, be regarded as a possible future source of power for the city of Halifax.

A special investigation of the Economy river was made at the request of the town of Amherst. This embraced a complete power and storage survey and a report showing power available and cost per unit of energy delivered to the outskirts of the town. On the findings of this investigation the town is examining the distribution problem with a view to making formal application to the Nova Scotia Power Commission for a supply of power.

At the present time a party supplied by the New Brunswick Electric Power Commission in charge of a Dominion Water Power Branch engineer is making a plane table and stadia survey above Grand falls on the St. John river to determine the flowage and pondage that will result from the proposed dam at the head of the falls.

Among special investigations carried out at the request of other towns were the following: Fales river near Kingston; Mulgrave brook and Pirates Cove brook near Mulgrave; river John near River John; Tupper Lake brook near Waterville; and the Digdeguash and two other small streams near St. George, N.B.

On the Tusket river in co-operation with the Nova Scotia Power Commission a topographical survey of Vaughan and Butler lakes was completed in order that the question of land damages resulting from a contemplated power dam at Tusket falls might be ascertained.

In the office considerable attention and study was given to problems resulting from the projects of the New Brunswick Electric Power Commission and the Nova Scotia Power Commission. Formal applications to the Nova Scotia Power Commission for power emanating from the district from Middleton to Yarmouth and Yarmouth to Pubnico necessitated a very careful study by the commission's engineers of three projects, namely, Bear river, Tusket river and Pubnico river and the Dominion Water Power Branch engineers lent valuable assistance in the work. Branch officials also prepared estimates of the cost of delivering more power to the city of Halifax from several alternative sources. They also assisted in the engineering design of the Sheet Harbour project, in field work and office computations relative to the Bear River project and on many other problems of a similar nature. In the case of the Musquash development in New Brunswick the water supply and power available from the plant were the subject of much bitter controversy in St. John and statements from this office covering the points at issue were prepared from time to time.

In addition to the extensive use made of the water supply records by the Provincial Power Commissions many requests for records have been received from individuals or corporations.

CONSTRUCTION

The fiscal year 1922-23 witnessed the completion of the St. Margaret Bay and Musquash developments, details of which were presented in last year's report.

Among new developments, that of the Nova Scotia Power Commission at East River, Sheet Harbour, is the the most important. This development is situated at Malay falls and will consist of two 1,800-horsepower units under a head of 43 feet with provision for a third 1,800-horsepower unit for future use. The initial development will deliver some 5,600,000 kilowatt-hours per year to Pictou county. A small development was commenced in July by the towns of Waterville and Cambridge utilizing water from Tupper Lake brook under a head of 300 feet. The plant will develop 75 horse-power and was very nearly completed when work was stopped temporarily for the winter.

CLASSIFIED LIST OF REPORTS

The Reports published by the Dominion Water Power Branch, with the exception of the Annual Reports, have been called Water Resources Papers, and have been numbered 1, 2, etc.

Annual Reports previous to 1913 are included with the Annual Report of the Department of the Interior, and can be secured from the secretary of the department.

Annual Reports for the fiscal years ending March 31, from 1913 to 1923, are available for distribution.

REPORTS OF SPECIAL OR GENERAL INTEREST

Water Resources Paper No. 2.—Report on Bow River Power and Storage Investigations (Bow river west of Calgary), by M. C. Hendry, chief engineer in charge of surveys. This is a complete study of the Bow river west of Calgary. It deals with meteorological conditions and their effect on run-off and ice formation. Existing and possible power and storage developments, together with maps and plans are appended complete. Published 1914.

Water Resources Paper No. 3.—Report on Power and Storage Investigations, Winnipeg River, by J. T. Johnston, chief hydraulic engineer, Dominion Water Power Branch. A complete study based on field surveys and office computations of the Winnipeg River basin; deals fully with history, international considerations, topography, climate, storage possibilities; describes existing and gives preliminary designs and estimates for possible power developments; discusses other sources of power and the power market. Maps, plans and all relevant data are appended. Published 1915.

Water Resources Paper No. 5.—Preliminary Report on the Pasquia Reclamation Project, by T. H. Dunn, chief engineer in charge of Reclamation Survey. This is a progress report of investigations carried out to determine the possibility of lowering the level of Cedar lake and its effect in a general scheme for reclaiming the low-lying lands contiguous to the Saskatchewan river in the Pasquia region. Published 1914. Out of print.

Water Resources Paper No. 6.—Report on cost of various sources of power for pumping in connection with the South Saskatchewan Water Supply Diversion Project, by H. E. M. Kensit. It deals with the problem of power for pumping water from the South Saskatchewan river for the supply of cities and towns in the central portion of south Saskatchewan. Published 1914. Out of print.

Water Resources Paper No. 7.—Report on the Manitoba Water Powers, by D. L. McLean, S. S. Scovil and J. T. Johnston, compiled for the Manitoba Public Utilities Commission. A general survey of the water-power situation in Manitoba, with all available general information and hydrometric data published to date in condensed form concerning the rivers in Manitoba. Published 1914.

Water Resources Paper No. 10.—General Guide for Compilation of Water Power Reports of Dominion Water Power Branch, prepared for the guidance of field engineers of the Dominion Water Power Branch, by J. T. Johnston, chief hydraulic engineer. Published 1915. Limited edition.

Water Resources Paper No. 11.—Second Report on the Pasquia Reclamation Project by T. H. Dunn, chief engineer in charge of Reclamation Survey. This is a continuation report based on further investigations as outlined under Water Resources Paper No. 5. Published 1915. Out of print.

Water Resources Paper No. 12.—Report on Small Water Powers in Western Canada, and discussion on sources of power for the Farm, by A. M. Beale. Part I is a brief description of certain small western water-power developments. Part II gives an analysis of requirements and cost data for the farm power supply. Published 1915. Out of print.

Water Resources Paper No. 13.—Report on the Coquitlam-Buntzen Hydro-Electric Development. A complete discription of the project and of the details of construction, with plans, diagrams and illustrations, by G. R. G. Conway, chief engineer of the British Columbia Electric Railway Company, Limited. Published 1915.

Water Resources Paper No. 16.—Water Powers of Canada. A series of five pamphlets in one volume covering the water-power situation in Canada, prepared for distribution at the Panama Pacific Exposition, San Francisco, 1915, by G. R. G. Conway, consulting engineer Toronto; Percival H. Mitchell, consulting engineer, Toronto; H. G. Acres, hydraulic Engineer, Hydro-Electric Power Commission, Ontario; F. T. Kaelin, assistant chief engineer, Shawinigan Water and Power Co., Montreal; K. H. Smith, engineer, Nova Scotia Water Power Commission, Halifax, N.S. Published 1916.

Water Resources Paper No. 17.—Canadian Hydraulic Power Development and Electric Power in Canadian Industry, by Charles H. Mitchell, consulting engineer to Dominion Water Power Branch. Part I deals with progress of utilization, features in design, construction and operation specially applicable to Canada. Description of certain typical Canadian water-power developments. Part II analyses the uses, growth and future of electrical power in Canadian industry. Published 1916.

Water Resources Paper No. 20.—Report on the Interests Dependent on Winnipeg River Power, with Special Reference to the Capital Invested and the Labour Employed, by H. E. M. Kensit. A detailed study of the industrial growth and future power requirements of the district tributary to the Winnipeg River power sites. Published 1917. Out of print.

Water Resources Paper No. 27.—Directory of Central Electric Stations in Canada to January 1, 1919, compiled by J. T. Johnston, assistant director, Dominion Water Power Branch. Comprises an analysis of the central electric census statistics and a directory of the stations. Published 1919. Out of print.

Water Resources Paper No. 32.—Water Resources Index Inventory, by J. T. Johnston. Description of the Index Inventory System for recording and collating the water resources data of the Dominion. Published 1922.

Water Resources Paper No. 33.—Directory of Central Electric Stations in Canada to November 1, 1922. Comprises an analysis of the central electric station statistics and a directory of the stations. Published 1923.

SURFACE WATER SUPPLY REPORTS

ATLANTIC DRAINAGE SOUTH OF ST. LAWRENCE RIVER INCLUDING NOVA SCOTIA, NEW BRUNSWICK, PRINCE EDWARD ISLAND, AND SOUTHEASTERN QUEBEC.

Water Resources Papers Nos. 29 and 37.—Surface water supply of Canada. Report on hydrometric surveys covering the Atlantic drainage south of the St. Lawrence river, including Nova Scotia, New Brunswick, and Prince Edward Island and southeastern Quebec, for the climatic years ending September 30, 1920 and 1921, by K. H. Smith, district chief engineer.

ST. LAWRENCE AND SOUTHERN HUDSON BAY DRAINAGE IN ONTARIO

Water Resources Papers Nos. 28, 34 and 38.—Surface water supply of Canada. Reports on hydrometric surveys covering the St. Lawrence and southern Hudson Bay drainage in Ontario for the climatic years ending September 30, 1920, 1921 and 1922, by S. S. Scovil, district chief engineer.

ARCTIC AND WESTERN HUDSON BAY DRAINAGE (AND MISSISSIPPI DRAINAGE IN CANADA) IN ALBERTA, SASKATCHEWAN, MANITOBA, EXTREME WESTERN ONTARIO, AND NORTHWEST TERRITORIES

Water Resources Papers Nos. 4, 19, 22, 24 and 26.—Surface water supply of Canada Reports on hydrometric surveys in Manitoba, from January 1, 1912, to September 30, 1919, by M. C. Hendry and C. H. Attwood, chief engineers. No. 4 contains a gazetteer of lakes and streams in Manitoba.

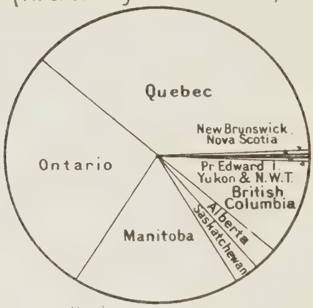
Water Resources Papers Nos. 31, 36 and 40.—Surface water supply of Canada. Reports on hydrometric surveys covering the Arctic and western Hudson Bay drainage (and Mississippi drainage in Canada) in Alberta, Saskatchewan, Manitoba, extreme western Ontario and the Northwest Territories, for the climatic years ending September 30, 1920, 1921 and 1922, by C. H. Attwood and A. L. Ford, district chief engineers. Previous to 1919-1920 the surveys in Alberta and Saskatchewan were carried on and the results published by the Reclamation Service, Department of the Interior.

PACIFIC DRAINAGE IN BRITISH COLUMBIA AND THE YUKON TERRITORY

Water Resources Papers Nos. 1, 8, 14, 18, 21, 23, 25, 30, 35 and 39.—Surface water supply of Canada. Reports on hydrometric surveys covering the Pacific drainage in British Columbia and the Yukon Territory from May, 1911, to September 30, 1922. No. 1 is by P. A. Carson, chief engineer, the others by R. G. Swan, district chief engineer. No. 1 contains an outline of the history of the Railway Belt with special reference to its administrative, legal and physical problems in regard to water, and a gazetteer of the lakes and streams in British Columbia.

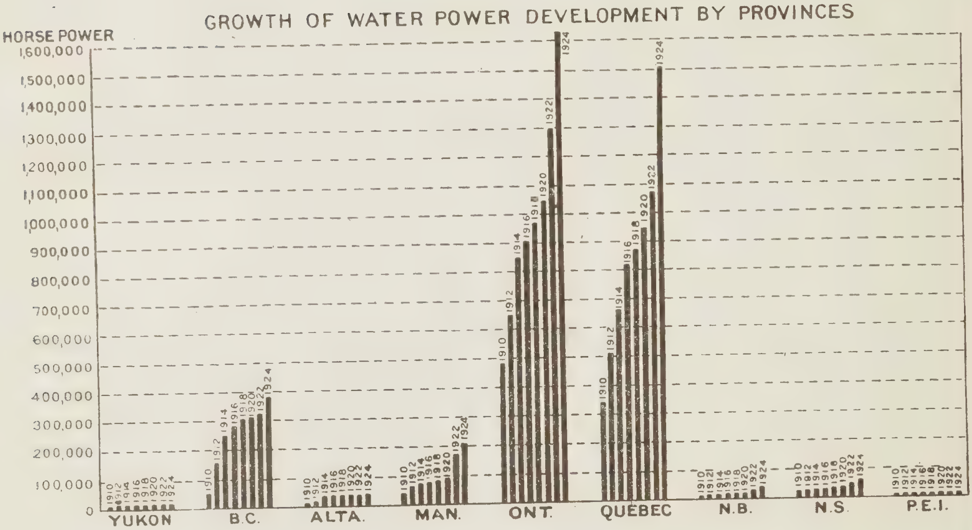
WATER POWERS OF CANADA

AVAILABLE WATER POWER BY PROVINCES
(At ordinary minimum flow)

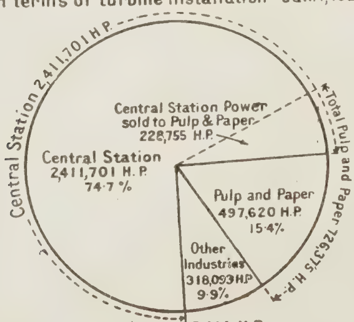


Total ordinary minimum 18,255,000 H.P.
Total ordinary 6 months 32,076,000 H.P.

GROWTH OF WATER POWER DEVELOPMENT BY PROVINCES



UTILIZATION OF DEVELOPED WATER POWER
(In terms of turbine installation—Jan. 1, 1924.)



TOTAL—3,227,414 H.P.

DEPARTMENT OF THE INTERIOR, CANADA

Hon. CHARLES STEWART, Minister W. W. CORY, C.M.G., Deputy Minister

DOMINION WATER POWER AND RECLAMATION SERVICE

J. B. CHALLIES, C.E., Director

ANNUAL REPORT

OF THE

DOMINION WATER POWER

AND

RECLAMATION SERVICE

FOR THE

Fiscal Year Ending March 31, 1924

OTTAWA
F. A. ACLAND
PRINTER TO THE KING'S MOST EXCELLENT MAJESTY
1925

92246—1½

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ANNUAL REPORT

OF THE

DOMINION WATER POWER AND RECLAMATION SERVICE

PART I

INTRODUCTORY

WATER POWER AND RECLAMATION

PART I

INTRODUCTORY

The past fiscal year was noteworthy by reason of the amalgamation effected of the Dominion Water-Power Branch and the Reclamation Service. This amalgamation proceeded gradually without any, even temporary, dislocation of the work of either branch. In view of the varied administrative responsibilities of the combined services it will be more convenient to outline their organization under the main divisions of activity namely: Water-Power, Irrigation and Drainage.

Organization

WATER-POWER

The water-power activities are both administrative and investigatory. The administrative phase of the work arises from the proprietary interest of the Dominion in the water resources in the provinces of Alberta, Saskatchewan, and Manitoba, the Northwest and Yukon Territories, and in the Railway Belt of British Columbia. In this connection the department must of necessity secure such fundamental engineering and economic data as will enable it to consider applications for power privileges, and to control the development, the distribution, and the sale of hydro-electric energy. This is the prime responsibility of the service.

Throughout the balance of the Dominion the water-powers are vested in the provinces, and investigatory work is carried on in co-operation with the respective provincial authorities charged with their administration. The service also co-operates extensively with federal departments and commissions other than the Department of the Interior, the services of its engineering field staff in the interests of general economy and efficiency, being made available to such other departments and commissions.

The co-operative facilities for water-resources investigation work throughout the Dominion are as follows:—

British Columbia.—The local organization, with headquarters at 119 Pender street west, Vancouver, carries on a broadly planned hydrometric survey and systematically secures fundamental data necessary to a complete analysis of the water-power resources, in accordance with the terms of a co-operative agreement with the Provincial Water Rights Branch of British Columbia.

Alberta and Saskatchewan.—The local organization, with headquarters in the Southam Building, Calgary, carries on direct administrative work throughout all parts of the two provinces, in virtue of the proprietary interest of the department in their water-power resources. The investigatory work comprises a comprehensive hydrometric survey and a systematic and exhaustive field and office analysis of the water-power resources of the two provinces. With the amalgamation of the Dominion Water Power Branch and Reclamation Service, the Commissioner of Irrigation, as ranking officer in Calgary, has been placed in administrative control of the combined organizations. The irrigation and drainage activities of the service are outlined at the end of this part of the report and are dealt with in detail in Part III.

Manitoba.—The local organization, with headquarters at 231 Chambers of Commerce Block, Winnipeg, carries on direct administrative work throughout the province, in virtue of the proprietary interest of the department in the provincial water-power resources. A comprehensive hydrometric survey is maintained, as well as a systematic and exhaustive field and office analysis of the provincial water-power resources. In the interests of administrative economy the investigatory work carried on through the Manitoba office has been extended to cover that portion of Ontario lying west of, and including lake Nipigon.

Ontario.—The local organization, with headquarters at Ottawa, carries on a comprehensive hydrometric survey and systematically secures fundamental water-resources data in accordance with the terms of a co-operative agreement with the Ontario authorities. The closest co-operation is maintained with the staff of the Ontario Hydro-Electric Power Commission.

Quebec.—The local organization, recently established with headquarters at 201 Inspector street, Montreal, is developing a comprehensive hydrometric survey and has under way the systematic collection of fundamental water-resources data as required by the terms of the co-operative agreement with the Quebec authorities. The closest co-operation is being maintained with the staff of the Quebec Streams Commission.

The Maritime Provinces.—The local organization, with headquarters at 193 Hollis street, Halifax, in accordance with the terms of a co-operative agreement with the three respective provincial authorities of New Brunswick, Nova Scotia, and Prince Edward Island, carries on a systematic hydrometric survey and a comprehensive and continuous power and storage survey of the three provinces, with a view to securing the fundamental data necessary to a complete analysis of their water-power resources. In New Brunswick, the branch collaborates with the New Brunswick Electric Power Commission; in Nova Scotia with Nova Scotia Power Commission; and in Prince Edward Island with the provincial authorities.

Yukon and Northwest Territories.—Administrative and investigatory work in the Territories form a direct responsibility of the water-power organization in virtue of the proprietary interest of the department in their water-power resources. Investigatory work in the Yukon is handled through the British Columbia organization. In the balance of the Territories such work is directed from head offices, as exigencies demand.

The water-power field organization is based upon and built up around the Dominion Hydrometric Survey staff through which systematic and continuous stream measurement studies are carried on throughout the Dominion. The hydrometric survey field staff are employed in a systematic and continuous field analysis of the country's water-power resources. The data systematically accumulated through this work and through co-operative agreements and studies with other organizations are collated, analysed, and standardized in the head office of the service at Ottawa.

As a result, there is now on file in the Ottawa office general and detailed information in respect to run-off and power possibilities of the more important power rivers throughout the Dominion. These data are constantly being brought up to date as new or later information is received and is promptly available for reference purposes to all interested in the utilization of the water-powers of the Dominion.

Irrigation

The irrigation activities are based upon the administration of the Federal Irrigation Act of 1894. Under the provisions of this Act the ownership of all surface water supply in the provinces of Alberta, Saskatchewan, and northern Manitoba is vested in the Crown and the Act provides means for granting rights

to use the available water for domestic, municipal, industrial, and other purposes. All licenses for the use of water are conditional upon continuous beneficial use and may be cancelled for abandonment or waste.

The local organization in charge of the Commissioner of Irrigation, with headquarters in the Southam Building, Calgary, is responsible for the field administration. This work consists in making preliminary surveys throughout the districts of deficient precipitation in sufficient detail to determine the feasibility of irrigation projects, to approve the plans for the construction of works which must accompany the application for a water license, to investigate the water supply, and keep a record of the amounts of water granted in order to insure that there is sufficient water available to meet the needs of the applicant.

The water supply in Alberta and Saskatchewan is sufficient to irrigate only a small percentage of the lands which might be benefited, and another activity of the service is to determine the "duty of water" in accordance with varied localities and soils in order that the available supply may be used to the best advantage in the interest of the greatest number. This necessitates a series of careful experiments extending over a period of years to determine the depth of water, time, and method of application required to produce maximum yields of the various crops which are grown under irrigation.

Drainage

The Federal Drainage Regulations, established by Order in Council by virtue of the Reclamation Act and the Dominion Lands Act, vest in the Minister of the Interior the right to drain and sell Dominion land or to grant the right to individuals or to the provincial drainage departments to drain bodies of water in the provinces of Alberta and Saskatchewan and Dominion land thereby reclaimed may be sold by the department under the provisions of the said Drainage Regulations.

The administration of the Reclamation Act and Drainage Regulations is conducted by this service with headquarters at Ottawa. Field investigations, inspections and surveys in connection with drainage in the provinces of Alberta and Saskatchewan are carried out by the field staff of the Commissioner of Irrigation, Calgary, on instructions issued from Ottawa. In the provinces of Manitoba and British Columbia questions of drainage in which this department may be interested are dealt with through the offices of the district chief engineers of this service. The closest co-operation is maintained with the provincial drainage departments at all times

Publications

A list of the Annual Reports, Water Resources Papers, and Reclamation Reports published to date will be found at the end of this report, and copies of those still in print will be sent on application to those interested, free of charge, except in the case of the Directory of Central Electric Stations for which a charge of 50 cents is made.

Bulletins were published dealing with: Hydro-electric Progress in Canada during 1923; The Water-Power Resources of Canada, February 1, 1924; Water-Power in the Pulp and Paper Industry in Canada, and The Utilization of Water-Power in Canada in relation to Coal Production, Importation and Consumption. Bulletins are now in course of preparation dealing with: Water-Power in Central Electric Station Industry in Canada, and Water-Power in the Mining Industry in Canada.

The Directory of Central Electric Stations in Canada, Water Resources Paper No. 33, supersedes the previous directory issued in 1919, and gives definite information as at November 1, 1922, in regard to all Central Electric Stations in Canada, of organization, officials, capitalization, history, primary and secondary power installation, transmission and distribution systems, municipalities served, electrical output, load conditions, use of power, blocks of power for sale, rates and available transportation.

PART II

WATER-POWER

PART II.

WATER-POWER

(a) Head Office

Lake of the Woods Control Board

The Lake of the Woods Control Board was, as in previous years, responsible for the regulation of the level and outflow of the lake of the Woods.

As heretofore regulation of the lake of the Woods embraced continuous collection of hydrological data relating to the watershed. In this connection the board was indebted to the Department of Public Works for run-off records pertaining to Rainy and Namakan lakes. Unusually high snowfall during the winter necessitated the full opening of the Norman dam in April but with low precipitation immediately preceding and following break-up it was found possible to close the Norman dam the same month. Owing to abnormally low precipitation during the remainder of the year lake level dropped from an elevation of 1,060.4 feet on July 17, to an elevation of 1,057.6 feet on March 31.

Detailed field and office investigations of the most feasible and economical method of providing an increased outflow capacity from the lake of the Woods were completed during the year. The board, in its final report, made recommendations as to the enlargement of the western outlet of the lake and the provision of a suitable control structure, together with estimates of the cost thereof.

An investigation was made of the storage potentialities of the boundary waters tributary to Rainy lake. In addition continuous records of lake level and outflow of lac Seul were secured throughout the year, together with information relative to the power resources of the English river.

Water-Power Regulations and Legal Research

The present Dominion Water-Power Regulations under which water-powers situated on lands of the Dominion are leased for development purposes, are dated October 31, 1921, and have not since been changed. Four priority permits, which give applicants for power privileges a certain degree of priority in the consideration of their development plans over other possible applicants, are at present in force under these regulations. They deal with a power site on the Nelson river, one on the Winnipeg river, and two on the Grass river in north-eastern Manitoba.

Two power companies which acquired their preliminary rights under the former regulations have applied for final licenses under the new regulations, modified in accordance with their existing rights, and these are now being prepared.

The systematic study of the laws passed by the various legislative bodies in Canada since their inception dealing with the uses of water, more especially for power purposes, which was referred to in the last annual report, has been continued during the year. This survey of the legal principles and administrative procedure which form the basis of water-power development throughout Canada is substantially completed as regards British Columbia, the Prairie Provinces, Nova Scotia, New Brunswick, and Prince Edward Island, and some progress has been made with Ontario and Quebec.

As regards the study of foreign water-power legislation and administration which has been in progress for some years, the record of acts and regulations relating to Switzerland, Spain, and Portugal was brought up-to-date, also those at present available relating to Russia and Japan.

British Columbia Administration

In the Railway Belt in British Columbia the waters and water-powers, although they form part of the public property of the Dominion, are administered by the provincial authorities (except within the Dominion Parks) under the provincial Water Acts; and the Dominion lands within the Railway Belt are administered by the Department of the Interior, the two systems of administration working together in a very satisfactory manner. The responsible officers of this department are enabled to exercise a proper degree of supervision over Dominion interests in the waters and in the other natural resources affected by their use, and at the same time a uniform method of acquiring water rights for all purposes has been established throughout the province.

The Burrard Power Company has been authorized by the province to develop power on Stave lake and river by erecting a dam at the foot of Alouette lake and diverting the waters of that lake into the Stave Lake watershed, by means of a tunnel. This will necessarily affect the natural flow of the Alouette river and consequently its use for floating purposes by the licensees of the Crown timber berths surrounding Alouette lake.

In order to protect the interests of those licensees, this department stipulated that proper provision should be made for passing logs over the dam, and for releasing a reasonable flow of water when necessary. The plans of the dam as approved by the Comptroller of Water Rights are satisfactory to the department in that respect, and have been accepted by the timber licensees.

The examination of water records, issued by the province, appurtenant to lands within the Railway Belt has been continued, and the granting of necessary rights of use or occupation of Dominion lands under the Water Lands Regulations is proceeding satisfactorily in co-operation with the British Columbia Lands Branch and the Forestry Branch of this department.

A large amount of work was done in the Railway Belt by the service engineers on behalf of the Department of Indian Affairs during the past year. Reports were prepared dealing with systems of water supply for the Indian reserves for irrigation, domestic, and other purposes, and works of this nature authorized by the Indian Department were carried out under the supervision of the service engineers.

The following are the more important investigations made and works constructed or begun within the year: Water supply systems to serve Indian reserves at Metlakatla, Church House, Sechelt, Fraser lake and near Chilliwack; irrigation systems for the North Thompson and Stone Indian reserves; sewage disposal plants for Indian schools at Sardis and Kamloops; and an electric lighting system at cape Mudge.

In addition to this engineering work, a large amount of material was collected in support of the Indian claims for water rights appurtenant to their reserves, and presented to the Board of Investigation, at their hearings under the Water Act. Plans and other information called for by Board Orders were also prepared and efforts made to expedite the issue of the water licenses which have been granted in response to the Indian claims.

Water Resources Index Inventory

The index inventory system devised by the service and applied to the recording and collating of the water-resources data of the Dominion, has now been in actual use for a number of years. A comprehensive description of this system has been given in a previous annual report.

The application of the system has been found most advantageous in practically every phase of the activities carried on by the organization, particularly in the complete census of developed water-power, the analysis of central electric station activities and the analysis of undeveloped water-power resources, stream measurement activities and storage studies.

As a result of this work having been largely carried on in co-operation with provincial organizations, notably the Hydro-Electric Power Commission of Ontario, the Quebec Streams Commission, the Water Rights Branch of British Columbia, the New Brunswick Electric Power Commission and the Nova Scotia Power Commission, there has been compiled a very large amount of water-resources data in standardized and usable form for whatever purpose required. A sustained effort is made to keep this information authentic and up-to-date.

In this connection the analysis of the water-power resources of the Dominion was actively carried on during the year both in the head office and in the various district offices. More detailed reference to field investigations and office studies will be found in the reports of the district chief engineers found in another part of this report.

Water-Power Resources of Canada

While complete data regarding Canada's great water-power resources are not yet available a great mass of reasonably accurate as well as considerable specific data is now available in the records of the Dominion Water Power and Reclamation Service of the Department of the Interior. During the past four years all existing stream-flow and power data available from federal, provincial and private sources have been systematically collated, re-analysed and co-ordinated with a view to preparing revised estimates of available power based on uniform methods of computation and arrangement.

BASIS OF COMPUTATION

The figures of undeveloped water-power listed in Table I are based upon rapids, falls, and power sites of which the actual existent drop or the head possible of concentration, is definitely established or at least well authenticated. Many rapids and falls of greater or lesser power capacity are scattered on rivers and streams from coast to coast which are not as yet recorded, and which will only become available for tabulation as more detailed survey work is undertaken and completed. This is particularly true in the relatively unexplored northern districts. Nor is any consideration given to the power concentrations which are feasible on rivers and streams of gradual gradient, where economic heads may be created by the construction of power dams, excepting only at such points as definite studies have been carried out and the results made matters of record.

In brief, the figures hereunder are based on definite rapids, falls, and power sites, and may be said to represent the *minimum water-power possibilities* of the Dominion.

The power estimates have been calculated on the basis of 24-hour power at 80 per cent efficiency for conditions of "Ordinary Minimum Flow" and "Ordinary Six-Months Flow." The "Ordinary Minimum Flow" is based on the averages of the minimum flow for the lowest two consecutive seven-day periods in each year, over the period for which records are available. The "Ordinary Six-Months Flow" is based upon the continuous power indicated by the flow of the stream for six months in the year. The actual method to determine this flow is to arrange the months of each year according to the day of the lowest flow in each. The lowest of the six high months is taken as the basic month. The average flow of the lowest seven consecutive days in this month determines the maximum for that year. The average of such maximum figures for all years in the period for which data are available is the estimated maximum used in the calculation.

This estimated maximum development is based upon the assumption that it is good commercial practice to develop wheel installation up to an amount, the continued operation of which can be assured during six months of the year, on the assumption that the deficiency in power during the remainder of the year can be profitably provided from storage or by the installation of fuel-power plants as auxiliaries. The correctness or otherwise of this assumption for any particular site can only be definitely settled by careful consideration of all circumstances and conditions pertinent to its development. The method, however, enables us to make a fairly satisfactory over-all estimate of the maximum hydraulic power available as distinctive from the estimated ordinary minimum power available.

AVAILABLE AND DEVELOPED TOTALS

The known available water-power in Canada, from all sources and within the limitations outlined, is 18,255,000 horse-power for conditions of ordinary minimum flow and 32,076,000 horse-power under a flow estimated for maximum development, i.e. dependable for at least six months of the year.

It is believed that these are conservative estimates, since an analysis of the water-power plants scattered from coast to coast concerning which complete data are available as to turbine installation and satisfactory information as to stream flow, gives an average machine installation 30 per cent greater than the six-month flow maximum power. Applying this, the figures quoted above, therefore, indicate that *the present recorded water-power resources* of the Dominion will permit of a turbine installation of 41,700,000 horse-power.

The total installation to February 1, 1924, in water-wheels and turbines throughout the Dominion is 3,227,414 horse-power. In other words the present turbine installation represents only *8 per cent* of the recorded water-power resources.

CURRENT PROGRESS IN DEVELOPMENT

The year 1923 was one of marked activity in the development of the Dominion's water-power resources, the addition of 255,000 horse-power during the year bringing the total water-power installation in Canada to 3,228,000 horse-power. The most significant feature however is the large number of projects actually in progress of construction or actively in prospect. These projects when complete will add to Canada's total more than 900,000 horse-power.

British Columbia.—Hydro-electric construction activities were carried on in British Columbia during 1923 at widely separated points. In the northern coastal district the Granby Consolidated Mining and Smelting Company completed the construction of a large storage dam on Falls creek and added a 5,000-horsepower unit in their hydro-electric station. The Pacific Mills Limited at Ocean Falls also extended their water storage facilities by raising their dam an additional fifteen feet and added a new 6,300-horsepower unit in their hydro station. The work carried on for the past two years by the British Columbia Electric Railway Company in raising their dam at the outlet of Stave lake was completed during 1923 and plans were laid for extensive new developments on the Stave river which will yield an additional 115,000 horse-power. In this connection tenders were being called towards the end of 1923 for a new unit of 25,000 horse-power to be erected and in operation during 1924. The East Kootenay Power Company actively carried on the construction of a new plant on the Elk river near Elko to have an initial installation of 15,000 horse-power and an ultimate capacity of 24,000 horse-power with regard to prospective developments it has been stated that the West Kootenay Power and Light Company are planning to double their capacity at Bonnington falls on the Kootenay river. It is also of interest to record a comprehensive report made by Kerry and Chace Limited, consulting engineers for the city of Vancouver, with regard to a systematic development of adjacent water-powers by the city.

Alberta.—The only hydro-electric project proceeded with in Alberta during the year was a small development undertaken by the Dominion Parks Branch of the Department of the Interior on the Cascade river for the supply of Banff. This installation of 960 horse-power was nearing completion at the end of the year. A new contract was made by the Calgary Power Company with the city of Calgary for a term of five years which was mutually advantageous to both parties, the company agreeing to construct an additional transmission line during 1924 from their power plants on the Bow river to that city.

Manitoba.—The initial stage of the Manitoba Power Company's hydro-electric development on the Winnipeg river at Great Falls was brought to completion and two 28,000 horse-power units are now in operation. Plans are under way for the addition of a third unit of similar capacity during 1924. The ultimate installation will comprise six units. The city of Winnipeg, towards the end of 1923, awarded a contract for three new units of 7,000 horse-power each to be installed in the municipal hydro-electric station at Pointe du Bois on the Winnipeg river. This will bring the total capacity to 82,000 horse-power with provision still remaining for two additional units.

Ontario.—The development work of the Ontario Hydro-Electric Power Commission ranked first in Ontario during the year. At the Commission's gigantic Queenston plant on the Niagara river two new 55,000-horsepower units, numbers five and six, were brought into operation. It is expected that units seven and eight will be installed in 1924 which will bring the capacity to 440,000 horse-power; the ultimate total of 550,000 to 600,000 horse-power being reached by 1926. A new 20,000-horsepower unit was installed in the Ontario Power Company plants operated by the commission at Niagara Falls, this unit replacing a similar one which was destroyed in 1922. A new plant of 1,200-horsepower was constructed at Bingham chute on the South river to serve the Nipissing system, and work was started on the installation of a new pipe-line at Eugenia falls. On the Trent river construction was commenced of two new developments, at dams 8 and 9, of 6,600-horsepower and 4,800-horsepower respectively. These will serve the central Ontario system and are expected to be in operation in 1924. Operations were also commenced on the addition of two new units of 12,500 horse-power each in the Cameron Falls station on the Nipigon river to serve the Thunder Bay system.

In the mining district of northern Ontario the Northern Canada Power Company brought into operation their 8,000-horsepower plant at Sturgeon falls on the Mattagami river to serve the gold mines in the Porcupine area. The Great Northern Power Company also brought into operation their station at Indian chute on the Montreal river with two units of 2,000 horse-power each. Construction was started of a 25,000-horsepower development by the Hollinger Consolidated Gold Mines, Ltd., at Island falls on the Abitibi river with the expectation of delivering power at the company's mine and mill in 1924. The Spruce Falls Company completed a 2,500-horsepower development at Kapuskasing on the river of the same name for use in connection with a sulphite pulp plant at that point. In the Kenora district the Backus-Brooks Company installed two additional 1,200-horsepower units in their plant at Kenora and with four more of the same capacity installed early in 1924 the station will have a total capacity of 12,000 horse-power for use in connection with the company's pulp and paper mill. The Dryden Paper Company also completed an installation of 1,400 horse-power on the Wabigoon river.

Quebec.—In Quebec construction operations were actively carried forward on numerous developments, several being of large magnitude. At the Cedars plant of the Montreal Light, Heat and Power Consolidated on the St. Lawrence river two units were added of 11,300 horse-power each, with two further units of the same capacity to be added in 1924, which will bring the total capacity to

200,000 horse-power. The St. Maurice Power Company achieved remarkable progress in the construction of their 120,000-horsepower development at La Gabelle on the St. Maurice river and expect to deliver power during April, 1924. The Southern Canada Power Company awarded the contract for a 37,800-horsepower development at Hemming falls on the St. Francis river and construction work was placed under way. It is expected to have this plant ready for operation early in 1925. In the Ottawa district the Ottawa River Power Company commenced the construction of a development at Calumet falls on the Ottawa river near Bryson. This plant will have an initial installation of one or two units of 22,500 horse-power each and an ultimate capacity of 67,500 horse-power.

In the Lake St. John region the largest individual development in the province is under way at the Grand discharge on the Saguenay river. This plant which is being constructed for the Quebec Development Company is to have an initial installation of 320,000 horse-power. Good progress was made on the work of construction during 1923. The plant is expected to be in operation early in 1926. In the same region Price Brothers and Company, Ltd., completed the installation of an 11,000-horsepower development on the Chicoutimi river at Chicoutimi for use in their paper mills at Kenogami. The town of Jonquiere is also installing an additional 1,800 horse-power in its plant on the au Sable river.

On the south shore of the St. Lawrence the Lower St. Lawrence Power Company completed a hydro-electric installation of 3,700 horse-power on the Metis river to supply the district extending from Rimouski to Matane. A small development of 550 horse-power was also installed by the town of Megantic on the Chaudiere river. On the lower north shore of the St. Lawrence the St. Regis Paper Company commenced the construction of a 600-horsepower hydro-plant two miles east of Godbout river. In the northwestern part of the province the Northern Canada Power Company secured a lease from the Quebec Government of a site on the Quinze river and immediately commenced construction. The initial installation of 20,000 horse-power is expected to be completed in 1924 when the power will be transmitted for use in the gold mining district of Northern Ontario.

Among other water-power activities in Quebec during 1923 may be mentioned a development for the Laurentide Hydro-Electric Ltd., on the East Branch of the North river—1,865 horse-power; a new development of 1,200 horse-power for J. C. Wilson Ltd. on the North river near St. Jerome; an additional capacity of 4,500 horse-power to the plant of the Portneuf Hydraulic Company at St. Alban on the Ste. Anne de la Perade river; a 50-kilowatt hydro-electric plant on the Mattawin river near St. Michel des Saints; a 600-horse-power hydro-electric plant replacing a water-works plant at Buckingham on the Lievre river and a 1,350-horsepower hydro-electric plant on Mars river near Bagotville.

Of great importance to hydro-electric development in the province of Quebec is the work of the Quebec Streams Commission. The commission has carried out most valuable storage works such as the Gouin reservoir on the St. Maurice river, the Allard reservoir on the St. Francis river and reservoirs on the Ste. Anne de Beaupre river. They are engaged at present on a $2,500,000 dam at lake Kenogami in the Saguenay district which will most beneficially regulate the flow in the Chicoutimi and au Sable rivers to the advantage of the pulp and paper industries at Chicoutimi and Kenogami. The commission also has under way storage improvements in the basin of the Metis river at an estimated cost of $200,000. Another storage reservoir which was recently completed with the approval of the commission was one on lake Jacques Cartier to regulate the flow of the river of the same name.

New Brunswick.—In New Brunswick, at Aroostook falls on the river of the same name, the Halifax and New Brunswick Power Company completed extensive alteration to their hydro-electric development and replaced two old units of 750-horsepower capacity each by new units of 2,000 horse-power, thereby bringing the total capacity of the plant to 8,400 horse-power. A transmission line taking power from this plant is under construction, running from Bridgewater, Maine, to Woodstock, N.B., via Lakeville, Centreville and Hartland. The largest undeveloped power site in the Maritime provinces, Grand falls on the St. John river, has been under study by the New Brunswick Electric Power Commission during the year with the possibility of development being undertaken if all conditions are found favourable.

Nova Scotia.—The most notable construction work in Nova Scotia during 1923 was that carried on by the Nova Scotia Power Commission at Malay falls on the East River Sheet Harbour. This development which comprises three units with a total capacity of 5,500 horse-power was well advanced during the year and is expected to be in operation early in 1924 when power will be transmitted for use in a number of towns in Pictou county. Final arrangements were also made by the commission for a second development on East River Sheet Harbour to furnish power to the Albany Perforated Wrapping Paper Company of Albany, New York, for a pulp and paper mill at West River Sheet Harbour. This development which will have an initial capacity of 6,000 horse-power with provision for an increase to 9,000 horse-power is of particular interest inasmuch as it is attracting a new industry to the province. The Avon River Power Company practically completed a development of 2,300 horse-power on the Avon river to serve the town of Windsor. Work was started on a plant of about 100 horse-power situated on a small stream known as East river. The power will be transmitted a distance of about six miles for use in the town of Lockport.

UTILIZATION OF DEVELOPED WATER-POWER

The 3,227,414 horse-power at present installed in this country may be classified as follows. (See table 2).

2.411,701 horse-power in central stations for general distribution for all purposes.

497,620 horse-power installed in pulp and paper mills, not including 228,755 horse-power purchased by pulp and paper companies from central stations.

318,093 horse-power installed in industries other than central stations and pulp and paper mills.

The total installation for the Dominion averages 353 horse-power per thousand population, a figure which places Canada third in the per capita utilization of water-power among the countries of the world. Norway and Switzerland only having a higher per capita utilization.

PAST AND FUTURE GROWTH IN UTILIZATION OF WATER-POWER

The growth of water-power developments in Canada has been striking. Total installed horse-power, has grown from 975,000 to 3,227,000 since 1910, central station installation from 605,000 to 2,411,701 horse-power and pulp and paper installation from 191,000 to 498,000 horse-power.

There is every reason to believe that this rate of growth will not diminish. New uses for electric current of the greatest import in industrial processes and services are being constantly discovered. Canada's strategic advantage in the location of large reserves of water-power within transmission distance of her centres of population should attract special industries to these centres in increasing numbers. Population follows industry and at once an added market is

created for power for domestic and municipal uses. All the modern tendencies in the utilization of cheap power indicate that the rate of growth of hydro-electric development in Canada will increase rather than lessen.

Should the rate of installation since 1910 be maintained at its present rate there will be installed in 1925, 4,000,000 horse-power; in 1930, 5,000,000 horse-power; in 1935, 6,000,000 horse-power; and in 1940, 7,000,000 horse-power. These growth figures are considered conservative as the rate of growth since 1920 has been considerably in excess of the rate over the whole period from 1910. Available reserves are more than ample to take care of these future demands, as outlined, for a long time to come.

The water-power now developed in Canada represents an investment of over $687,000,000. In 1940, should the rate of growth in installation during the past fifteen years continue, this investment will have grown to over $1,500,000,000. The present development represents an annual equivalent of 29,000,000 tons of coal which, valued at $10 per ton, represents $290,000,000. In the year 1940 these annual figures will, with the foregoing assumption, have become 63,000,000 tons and $630,000,000. These figures are striking evidence of the outstanding importance and necessity of an intelligent administrative policy governing the development of our water-power resources.

Table 1.—Available and Developed Water-Power in Canada, February 1, 1924

Province	Available 24-hour power at 80 per cent efficiency		Turbine Installation
	At ordinary min. flow Horse-power	At ordinary 6-months flow Horse-power	Horse-power
1	2	3	4
British Columbia	1,931,142	5,103,460	355,517
Alberta	475,281	1,137,505	33.067
Saskatchewan	513.481	1.087.756	....
Manitoba	3,270,491	5,769,444	162,025
Ontario	4,950 300	6,808.190	1,445,480
Quebec	6,915,244	11,640,052	1,116,398
New Brunswick	50,406	120,807	44,539
Nova Scotia	20,751	128.264	54,950
Prince Edward Island	3 000	5 270	2,239
Yukon and Northwest Territories	125,220	275,250	13,199
	18,255,316	32,075,998	3,227,414

The figures listed in Columns 2 and 3 in the above table represent 24-hour power and are based upon rapids, falls, and power sites of which the actual existent drop or the head possible of concentration, is definitely known or at least well established. Many rapids and falls of greater or lesser power capacity are scattered on rivers and streams from coast to coast which are not as yet recorded, and which will only become available for tabulation as more detailed survey work is undertaken and completed. This is particularly true in the relatively unexplored northern districts. Nor is any consideration given to the power concentrations which are feasible on rivers and streams of gradual gradient, where economic heads may be created by the construction of power dams, excepting only at such points as definite studies have been carried out and the results made matters of record.

The figures in Column 4 represent the actual water-wheels installed throughout the Dominion. These figures should not be placed in direct comparison with the available power figures in Columns 2 and 3 for the purpose of deducing therefrom the percentage of the available water-power resources developed to date. The actual water-wheel installation throughout the Dominion averages 30 per cent greater than corresponding maximum available power figures calculated as in Column 3. The figures quoted above, therefore, indicate that the *at present recorded water-power resources* of the Dominion will permit of a turbine installation of *41,700,000* horse-power. In other words, the present turbine installation respresents only *8 per cent* of the present recorded water-power resources.

The above figures may be said to represent the *minimum water-power possibilities* of the Dominion.

As illustrative of this the detailed analyses which have been made of the water-power resources of the province of New Brunswick and Nova Scotia have disclosed most advantageous reservoir facilities for regulating stream flow and it is estimated that the two provinces possess within their respective borders 200,000 and 300,000 commercial horse-power. These figures provide for a diversity factor between installed power and consumers' demands.

Table 2.—Developed Water-Power in Canada—February 1, 1924

Province	Turbine Installation in Horse-power				Population June 1, 1923	Total installation per 1,000 population H.P.
	In Central Stations	In Pulp and Paper Mills	In Other Industries	Total		
1	2	3	4	5	6	7
British Columbia	242,401	55,140	57,976	355,517	553,500	642
Alberta	32,380	....	687	33,067	634,200	52
Saskatchewan	....	....	....	....	814,200	....
Manitoba	145,625	....	16,400	162,025	642,800	252
Ontario	1,142,403	174,189	128,988	1,445,480	3,028,900	477
Quebec	791,795	237,232	87,371	1,116,398	2,443,500	457
New Brunswick	23,613	13,728	7,198	44,539	396,900	112
Nova Scotia	23,196	17,331	14,423	54,950	532,600	103
Prince Edward Island	288	....	1,951	2,239	88,000	25
Yukon and Northwest Territory	10,000	....	3,199	13,199	11,400	1,158
Canada	2,411,701	497,620	318,093	3,227,414	9,146,000	353

Column 2 includes only hydro-electric stations which develop power for sale.

Column 3 includes only water-power *actually developed* by pulp and paper companies. In addition to this total, pulp and paper companies purchase from the hydro-power central stations totalled in column 2, 96,985 horse-power in Ontario, 131,120 horse-power in Quebec and 650 horse-power in New Brunswick. The total hydro-power utilized in the pulp and paper industry is therefore 726,375 horse-power.

Column 4 includes only water-power *actually developed* in connection with industries other than the central station and the pulp and paper industries. These industries also purchase blocks of power from the central stations totalled in Column 2.

Column 5 totals all turbines and water-wheels installed in Canada.

Column 6 Population at June 1, 1923, as estimated by Dominion Bureau of Statistics.

Column 7 averages the developed water-power per 1,000 population.

Water-power in the Central Electric Station Industry

Few realize the extent to which the industrial commercial and domestic life of Canada is dependent upon the Central Electric Station Industry, and even more, the extent to which this industry is in turn based upon the utilization of our unrivalled water-power resources. The continually expanding transmission systems of the great power systems are carrying ever-increasing amounts of electrical energy from the central supply stations to the industrial centres, and tapping ever-widening market areas. The resultant benefits of low-priced power; the advances in and brilliance of modern street lighting; the efficiencies and economies in industry; and the conveniences and advantages in the home are so well known as to need little emphasis here.

While these present day conditions are, as a rule, accepted as a matter of course by the public, a review of the basic facts underlying them will be found both instructive and impressive.

The Dominion Water Power and Reclamation Service has, in co-operation with the Bureau of Statistics of the Department of Trade and Commerce, made careful and systematic study of the development of the Central Station Industry in Canada since 1917. The summarization of data herein is devised to bring out the preponderating influence which water-power has had in the development and expansion of the industry. This is best evidenced by the fact that 94 per cent of the primary power installation in Central Electric Stations throughout Canada is water-power, and that 98 per cent of the total developed by such stations is hydro-electric power.

THE CENTRAL ELECTRIC STATION INDUSTRY

By Central Electric Stations are meant those organizations generating or distributing electrical power for public use so that the data included in this

review do not include particulars of the large number of plants where water or fuel-power is converted into electrical energy for use in the owner's manufacturing processes. The energy distributed may be generated by the organization distributing it, it may be purchased wholesale from some other organization, or part of it may be purchased and part generated by the distributor. Organizations generating all or part of the power they distribute are designated generating stations, while those purchasing all of the power they distribute are classed as non-generating stations. Each of these fundamental types of stations is still further divided according to character of ownership into commercial or privately owned and municipal or publicly owned stations.

The 6th annual census of this industry has just been completed under the terms of the co-operative agreement referred to above, and before presenting an analysis of the use of water-power therein a general statement regarding the growth and the extent of the industry in general might be made.

While some vague knowledge of the existence and powers of electricity has obtained for several centuries, it was not until the development of the electric generator and electric transformer within the last forty years that any general use of this powerful servant of mankind became possible. Since then the development of this industry has been phenomenal. The first census of the industry was taken in 1917, but for purposes of comparison the figures of the 1918 census are set against those of 1922 in Table 3.

Table 3.—Comparative Summary of Data

——	1922	1918
Total number of stations	905	795
Hydraulic stations	269	280
Fuel stations	253	235
Non-generating	383	280
Total capital invested	$ 568,068,752	$ 401,942,402
Total revenue from sale of power	82,328,866	53,549,133
Total number of employees	10,684	9,698
Equipment (main plant)—		
Total primary power (main plant)	2,258,398 H.P.	1,841,114 H.P.
Water wheels and turbines	2,112,289 H.P.	1,682,191 H.P.
Steam engines and steam turbines	130,029 H.P.	145,637 H.P.
Gas and oil engines	16,080 HP.	13,286 H.P.
Total secondary power-dynamos	1,736,199 KVA	1,433,722 KVA
Electric energy generated	6,740,750,000KWH	4,787,366,000KWH
Electric energy generated in hydraulic stations	6,570,091,000KWH	4,682,467,000KWH
Electric energy generated in fuel stations	157,583,000KWH	104,899,000KWH
Average kwh produced per kva capacity	3,885KWH	3,340 KWH

The salient features of the tabular comparison may be briefly stated as follows:—

There has been an increase of 110 or 13.8 per cent in the total number of stations made up of increases of 103 or 36.8 per cent among non-generating, 18 or 7.7 per cent among fuel-generating, and a decrease of 11 or 3.9 per cent among hydro-generating stations, concurrent with a decrease of 12,814 horse-power, or 8.1 per cent in the primary power installation of the fuel generating stations and an increase of 271,175 horse-power or 25.6 per cent in the installation of the hydraulic generating stations. The figures may almost be said to be self explanatory; the modern tendency towards consolidation has eliminated several small hydraulic generating stations in those provinces (British Columbia, Ontario and Quebec) where the larger hydraulic generating organizations with extensive transmission systems operate and has enabled many municipalities and distributing companies which would otherwise have had to maintain generating plants, to purchase blocks of power wholesale for distribu-

tion. Many of the fuel generating stations have also been dismantled when the areas they served have been reached by hydro-electricity and the reduction in the installed capacity of this class of station would be even more marked were it not for the constantly growing numbers of internal combustion plants serving the smaller urban centres of the Prairie Provinces.

The total capital investment has grown from $401,942,402 to $568,068,752, an increase of 41.3 per cent over 1918, while the total primary power installation of the main plants has increased from 1,841,114 to 2,258,398 horse-power, an increase of 22.7 per cent. It must be borne in mind in connection with this seeming discrepancy between capital and installation that much money is invested in power-houses, headworks, etc., more extensive than necessary for the initial installation and that, with the installation of further wheels, the ratio between capital and power will once more readjust itself.

The greater diversity of use to which power is now put is indicated by the fact that whereas in 1918 the average number of kilowatt-hours produced per kilovolt ampere of installed capacity was 3,340, by 1922 it has reached 3,885, indicating a very much more advantageous use of the equipment and capital employed.

The constantly increasing application of electricity to industrial, agricultural and domestic use indicates a steadily growing demand for power and that this will be available as required is evident from the large number of developments under construction or in prospect.

The importance of water-power to the central station industry at once becomes apparent when it is stated that the last completed annual census of the industry, that for the year 1922, showed that 93.5 per cent of the main plant primary power installation consisted of water-wheels and turbines, and that 97.7 per cent of the total output of electricity was generated by water-power. An analysis of the revenues of the generating stations showed that the average selling price per unit of power generated by the hydraulic stations was considerably less than the bare cost of fuel to produce each unit of power in the fuel stations, while the hours of service and extent of utilization was correspondingly in favour of the users of hydro-electricity.

A summary of the principal data for Canada and each of the provinces relating to the central stations distributing hydro-electricity is set forth in Table 4.

Of the 629 stations distributing hydro-electricity, 269 generated all or part of the energy they sold, while 360 were classed as non-generating stations. There were 262 commercial stations, of which 196 were generating, and 66 non-generating, and 367 municipal stations, of which 73 were classed as generating and 294 as non-generating.

The total capital invested in hydro-electric stations amounted to $542,562,972 or 95.5 per cent of the total capital of the industry. Of this amount $459,708,154 is invested in generating stations and $82,854,818, in non-generating stations. An interesting feature of the investment in non-generating stations is that $56,685,955, or over 68 per cent represents the investment of those municipalities distributing power purchased from the Hydro-Electric Power Commission of Ontario. The 262 commercial stations represent an investment of $319,228,868 of which $297,400,840 pertains to the generating and $21,828,028 to the non-generating stations, while the 367 municipal stations have a capital of $223,334,104, of which $162,307,314 is in generating and $61,026,790 in non-generating stations. Ontario, due largely to the extensive distribution systems of the municipalities served by the Hydro-Electric Power Commission, accounts for approximately 95 per cent of this latter amount.

The total revenue received from the sale of power to consumers is calculated by deducting from the gross revenue received from the sale of power the

cost to the purchasing stations of the power sold by one station to another. The total revenue so received amounted to $54,391,572 for the 6,570,091,000 k.w.h. generated representing an average cost to consumers of 0.828 cent per kilowatt-hour. Table 4 shows that this average selling price varied from 0.692 cent in Quebec to 13.115 cents in Prince Edward Island. Alberta was second lowest with a unit selling price of 0.697 cent although as pointed out in the footnotes to Table 4 this low-unit revenue is due to over 90 per cent of the total output being sold wholesale to a fuel generating station so that only a very small portion of the retail price is included. Ontario is third with 0.835 cent per kilowatt-hour. In connection with this latter figure it might be mentioned that the rates charged by the municipalities distributing energy purchased from the Hydro-Electric Power Commission of Ontario include a sinking fund payment which will in thirty years make the contracting municipalities owners of the entire system.

Ontario led the provinces in the generation of electricity with 3,145,741 thousands of kilowatt-hours, or approximately 48 per cent of the total production, while Quebec was second with 2,537,727 thousands of kilowatt-hours or 38.6 per cent.

Of the total urbine installation of 2,112,289 horse-power Ontario had 969,067 horse-power or 45.9 per cent, and in addition maintained fuel auxiliary equipment for use in case of accidents to station or distribution equipment or during periods of low water, totalling to 65,715 horse-power, Quebec had 755,258 horse-power in turbines and 32,605 horse-power in auxiliary fuel equipment, while British Columbia came third with 228,441 horse-power in turbines and 26,830 horse-power fuel auxiliary.

USE OF POWER SOLD BY HYDRO-ELECTRIC CENTRAL STATIONS

Because of the diversity of demand and also the widely varying uses to which electrical energy is put it is extremely difficult to compute what portion of the primary power installation of the central stations may be said to be installed for any specific use. A careful analysis of the reports on the uses of power sold would seem to indicate that approximately 30 per cent of the installation produced energy for lighting, 40 per cent divided equally among electric railway operation, export, mining and pulp and paper manufacturing, 5 per cent for electro-chemical and electro-metallurgical industries and 25 per cent for general manufacturing, water pumping and miscellaneous power purposes.

DEVELOPMENT SUBSEQUENT TO THE CENSUS OF 1922

Through advance information obtained from various sources it is possible to present a summary of the installation of hydro-electric central stations up to the beginning of the present year. This is shown in Table 5 and shows that the turbine installation has reached a total of 2,411,701 horse-power of which 1,644,701 horse-power is installed in commercial and 767,630 horse-power in municipal stations. Many additional large developments are at present under construction or in active prospect. In British Columbia the East Kootenay Power Company is constructing a 15,000-horsepower station at Elko, while the British Columbia Electric Railway Company is preparing to install a 25,000-horsepower unit in its Stave Falls station. The Manitoba Power Company has installed two units in its new station at Great falls and a third is now being added, while the city of Winnipeg intends adding three units, totalling 20,700 horse-power to its Pointe du Bois station. The Hydro-Electric Power Commission of Ontario have installed 130,600 horse-power in various stations since the beginning of 1923 and expect to add 147,000 horse-power during the present year. Power for the mining district of northern Ontario has been augmented by two installations, one of 4,000 horse-power and one of 8,000 horse-power,

while the Quinze River[1] development of the Northern Canada Power Company will provide an additional 20,000 horse-power. In Quebec, existing central stations have added some 30,000 horse-power to their equipment, while outstanding developments under construction include the great stations of the Quebec Development Company on the Saguenay river where 160,000 horse-power is expected to be in place by the end of 1924, and that of the St. Maurice Power Company at La Gabelle where 120,000 horse-power is now being installed. The Southern Canada Power Company's 33,600-horsepower station at Hemming falls and that of the Ottawa River Power Company at Calumet with 25,000 horse-power will also add to the total.

In the Maritime Provinces existing stations have added to their equipment and three new stations have been constructed or are in process of construction.

HYDRO-ELECTRIC POWER IS LOW COST POWER

The fact that hydro-electric power is available at low cost is largely responsible for the rapid development of the electro-chemical and electro-metallurgical, mining and mineral products and pulp and paper industries; cheap power being essential to the success of these industries, on account of the large amounts required for the different manufacturing processes employed. In very many cases large-scale operations, which alone make the difference between profit and loss, have been possible because of the cheap and abundant power supplied by the hydro-electric central stations, while in others the cost of capital required to develop their own power would have proved a heavy burden to industrial organizations. That Canada possesses sufficient water-power awaiting development to meet the needs of industry is evidenced by the figures of Table 1.

Table No. 4—Hydro-Electric Central Stations—Summary of Principal Data—January 1, 1923*

Province	No. of Stations			Capital Invested			[1]Revenue from Sale of Power to Consumers		
	Total	Generating	Non-Generating	Total	In Generating Stations	In Non-Generating Stations	Total	By Generating Stations	By Non-Generating Stations
1	2	3	4	5	6	7	8	9	10 *
				$	$	$	$	$	$
Canada...........	629	269	360	542,562,972	459.708,154	82,854,818	54,391,572	40,434,903	13,956,669
Alberta...........	8	4	4	5,678,789	5,632,172	46,617	469,831	461,979	7,852
British Columbia	40	27	13	47,259,535	39,404,751	7,854,784	5 645,981	3,637,614	2,008,367
Manitoba.........	11	4	7	22,465,932	20,097,716	2,368,216	3,018.295	2,777,215	241,080
New Brunswick..	13	9	4	1 948 497	1 850,428	98,069	401,663	380,934	20,729
Nova Scotia......	28	18	10	5,458,771	3,390,966	2,067,805	950,687	247,767	702,980
Ontario...........	375	105	270	292,323.001	231,677,017	60,645,984	26,232,633	16,848,815	9,383,818
Prince Edward Island..........	8	7	1	84,053	....	....	10,226	....	....
Quebec...........	144	94	50	165,886,657	156,363,352	9.523.305	17,566 381	15,994,913	1,571,468
Saskatchewan....	......	......	......	....	....	....	....	....	....
Yukon............	2	1	1	....	....	....	....	....	....

[1]*Revenue from sale of power to consumers* is computed by deducting from *total revenue from sale of power* the cost of power exchanged between stations.

[1] Wholly in the Province of Quebec.

* Continued on next page.

Table No. 4—Continued

Province	Electric Energy Generated	Revenue from Consumers per KWH	Turbine Installation	Fuel Auxiliary Installation
	11 K.W.H. Thousands	12 c.	13 H.P.	14 H.P.
Canada	6,570,691	0·828	2,112,289	150,257
Alberta	66,224	[2]0·697	32,560	2,350
British Columbia	517,393	1·092	228,441	26,830
Manitoba	260,307	1·159	89,625	12,346
New Brunswick	19,993	2·009	11,770	1,075
Nova Scotia	14,029	6·775	15,289	9,110
Ontario	3,145,741	0·835	969,067	65,715
Prince Edward Island	78	13·115	279	66
Quebec	2,537,727	0·692	755,258	32,605
Saskatchewan	....	....	....	....
Yukon	8,599	1·115	10,000	160

[2]This low unit revenue is due to the fact that over 90 per cent of the output of the hydro-electric stations is sold wholesale to a fuel-generating station so that only a very small proportion of the retail price is included.

Table 5.—Developed Water-Power in Canada Utilized in the Central Station Industry

Province	Commercial Stations			Municipal Stations			Installations				
	No.	Installations		No.	Installations		No.	Generator K.V.A.	H.P. per Turbine	H.P. per Station	Total Turbine H.P.
		Generator K.V.A.	Turbine H.P.		Generator K.V.A.	Turbine H.P.					
1	2	3	4	5	6	7	8	9	10	11	12
British Columbia	24	153,686	232,356	8	6,353	10,045	32	160,039	4,108	7,375	242,401
Alberta	3	22,250	32,380	......	....	....	3	22,250	2,414	10,793	32,380
Saskatchewan	......	....	....	......	....	....	......	....	....	....	....
Manitoba	4	58,350	78,400	2	57,312	67,225	6	115,662	6,935	24,271	145,625
Ontario	69	395,659	503,375	37	457,472	639,028	106	853,131	4,109	10,777	1,142,403
Quebec	79	606,813	771,820	17	14,962	19,975	96	621,775	3,552	8,248	791,795
New Brunswick	7	8,460	11,703	3	9,363	11,910	10	17,823	1,073	2,361	23,613
Nova Scotia	9	3,204	3,749	12	15,389	19,447	21	18,593	828	1,124	23,196
Prince Edward Island	7	331	288	......	....	....	7	331	32	41	288
Yukon	1	6,000	10,000	......	....	....	1	6,000	5,000	10,000	10,000
CANADA	203	1,254,753	1,644,071	79	560,851	767,630	282	1,815,604	3,682	8,552	2,411,701

Commercial Stations include all privately owned.
Municipal Stations include all publicly owned.
NOTE.—Statistics in this table are based upon a census of the industry made by the Dominion Bureau of Statistics in co-operation with the Dominion Water Power and Reclamation Service.

WATER-POWER IN THE PULP AND PAPER INDUSTRY

The importance of the pulp and paper industry to the national life of Canada is indicated by certain basic facts brought out by recent statistical investigation. Among these may be mentioned, (I) that the capital investment at January 1, 1923, amounted to over $380,000,000, a figure only exceeded by our investment in steam railways and central electric stations, (II) that the exports of the products of the industry during 1922 were valued at approximately $123,000,000 and were of greater value than those of any other group except vegetable products, (III) that the industry maintained a staff of 25,830 persons (exclusive altogether of the men employed in the woods) whose salaries and wages for the year 1922 amounted to $32,918,955, and that the value of the products for that year totalled $155,785,388.

LOW-COST POWER ESSENTIAL TO THE INDUSTRY

As it takes practically 100 horse-power to make one ton of paper per day the indispensibility of an abundant supply of low-priced power at once becomes apparent. In any industry the relative necessity of obtaining cheap and adequate power may be gauged by the amount required per dollar value of product, and with the possible exception of certain electro-chemical and metallurgical processes the requirements for the manufacture of pulp and paper rank among the highest.

It is therefore little surprising that over 90 per cent of the motive power in this industry is derived from the energy of our abundant and advantageously located waterfalls.

While stating the average consumption of power for the conversion of pulpwood into paper as 100 horse-power per ton per day, some average figures based on general conditions in the trade might be quoted to show how this large amount of power is used. One large and representative Canadian mill uses on the average 73 horse-power for each ton of mechanical pulp produced, 67 horse-power of which is for the actual grinding alone. The production of sulphite pulp for mixing with the groundwood pulp required 8.7 horse-power per ton of daily output (in other large mills as high as 30 horse-power was used per ton of sulphite pulp produced) while the conversion of the pulp to newsprint required 12 horse-power for the same unit of output.

The continuous operation of mills in this industry, usually 24 hours per day, lends itself to the securing of a very low cost per unit of power used where the power is derived from water, as the main item in this cost is the interest on the capital expended in the hydraulic development and this remains constant whether the plant operates ten hours per day or twenty-four. The development of the electric steam generator has also become an added factor in reducing this unit cost, in that any surplus or off-peak power which may be available can be utilized for producing steam for pulp cooking, drying, heating and similar uses.

WATER-POWER INSTALLATION FOR PULP AND PAPER MANUFACTURING

Having in mind the rapidly increasing importance of the pulp and paper industry in the development of the commerce and settlement of the country and the part which our water-power resources are destined to play therein, the Dominion Water Power and Reclamation Service, has conducted special studies in this connection and has gathered much information on power installation and requirements of pulp and paper mills operated by water-power or by purchased hydro-electric energy. For the sake of brevity the general term "pulp and paper mills" has been adopted throughout this review as including *pulp* mills, *pulp and paper* mills, and *paper* mills.

At the present time the hydraulic power utilized in the pulp and paper industry totals 726,375 horse-power and the rapidly growing change to the elastic electric drive is shown by the fact that 438,708 horse-power or over 60 per cent of this total is converted into electricity before use. Of this latter total, 210,053 horse-power is connected to generators installed in the mills and power stations belonging to the operating companies, while 228,755 horse-power is purchased from central electric stations. The advantages of this conversion to electricity appear both in the quality of the product which is improved by the uniform speed obtained and in the fact that under modern methods of transmission it is possible to develop power at one or more sites more or less remote from centres of labour and transportation, and to transmit it to points where these commodities are available for mill operation, and for providing supplies of raw materials and conveying the finished products to the markets. The best modern practice in pulp mill construction provides for the development of the mill and power sites as separate projects i.e. the site of the mill is selected

from the point of view of operation and transportation while the power station or stations may, if efficiency of development and generation demand it be placed in positions unfavourable to mill construction. The use of steam as a source of power for this industry is very limited and is in many cases prompted by special conditions such as operation in close connection with the manufacture of lumber when refuse from the latter can be used as fuel under the boilers.

The last completed census conducted by the Dominion Bureau of Statistics, that for the year 1922, shows a steam-power installation in pulp and paper mills of only 60,764 horse-power or less than 10 per cent of the total installation.

GENERAL CONDITIONS IN EACH PROVINCE

A rapid inspection of the date in Table 6 shows that the province of Quebec leads in number of mills and in both direct-connected and electrically driven installation. Ontario ranks second followed by British Columbia, Nova Scotia, and New Brunswick in the order named. There are no mills at present in operation in the Prairie Provinces.

Quebec has fifty-six mills driven by 368,352-horsepower hydraulic or hydro-electric energy. Of this, 151,792 horse-power is direct-connected to pulp and paper machines, 85,440 is connected to generators and 131,120 horse-power represents power purchased from central electric stations. Of this purchased power the nine mills which themselves generate no hydraulic power purchase 88,385 horse-power, the balance, 42,735 horse-power being additional power purchased by generating mills. The total daily producing capacity of these mills is some 3,000 tons of mechanical pulp, 1,500 tons of chemical pulp, 1,400 tons of newsprint and 740 tons of other kinds of paper. The three largest mills in the province, each requiring over 30,000 horse-power are situated at Grand'-Mère where all the hydro-electric energy is purchased, at Kenogami where power is obtained from three hydro-electric plants in addition to that produced at the mills and at Shawinigan where about fifty per cent of the power is purchased. Other large mills requiring between 10,000 and 25,000 horse-power are situated at Cap Madeleine, Three Rivers, East Angus, Brompton, Chicoutimi and Clarke City.

Ontario has forty-six mills requiring a total of 271,174 horse-power. Of this 174,189 horse-power made up of 89,066 direct-connected and 85,123 connected to generators is installed in the plants of the pulp and paper organizations while 96,985 horse-power is purchased from central electric stations. The total daily production of the mills in this province aggregate 2,200 tons of mechanical pulp, 1,800 tons of chemical pulp, 1,900 tons of newsprint and 735 tons of other kinds of paper. The largest mill in the province in power installation is at Iroquois Falls where turbines with a capacity totalling 52,000 horse-power are installed in two power stations. Another larger mill with a varied output is located at Ottawa and has an installation of 28,789 horse-power. Mills requiring from 10,000 to 20,000 horse-power each are numerous and include those at Sault Ste Marie, Espanola, Sturgeon Falls, Thorold, Fort Frances and Fort William.

British Columbia with only five mills has a total installation of 55,140 horse-power of which 26,790 is direct connected to pulp and paper machines and 28,350 is converted to electricity before use. None of these mills finds it necessary to supplement its own installation by purchased power. The two large mills at Ocean Falls and Powell River have installations of 26,850, and 24,000 horse-power respectively.

The combined production of the mills in this province reaches some 390 tons of mechanical and 430 tons of chemical pulp, 445 tons of newsprint and 30 tons of other papers daily.

New Brunswick has only four mills operated by water-power with a total installation of 13,728 horse-power and a daily producing capacity of 30 tons of mechanical and 300 tons of chemical pulp and 50 tons of newsprint paper.

Nova Scotia has ten mills operated by water-power. These mills are all of moderate size and have a total installation of 17,331 horse-power. Their daily producing capacity is some 200 tons of mechanical pulp and 50 tons of newsprint.

CHARACTERISTICS OF GEOGRAPHIC GROUPS

The location of the pulp and paper mills in Canada shows that they are grouped according to facilities for wood, power or transportation. The various mills of the same group show certain outstanding features with regard to power requirements as a result of the class of production which characterizes the group.

Table No. 7 has been prepared to illustrate predominating features in certain districts into which our Canadian mills may be arbitrarily grouped. Perhaps the greatest contrast exhibited in this table is between the class of mills found in the Niagara and Toronto, Eastern Ontario, Montreal and Quebec City groups, where a large number of mills (Column 2), whose average capacity is small (Column 6), produce much of the miscellaneous kinds of Paper (Column 9), while the British Columbia and more northerly groups in Ontario and Quebec comprise mills of large capacity (Column 6), requiring much power to produce principally pulp and newsprint (Column 7 and 8).

CONSTRUCTION ACTIVITIES

At the present time there is considerable activity in power development for new pulp mill construction and in providing additional power for existing mills. In this connection interest centres in the great development of the Grand Discharge on the Saguenay river which will have an ultimate capacity of 420,000 horse-power. Much of this great supply is destined for the pulp and paper trade, 200,000 horse-power being stated to be already under contract for use by the Price interests. The Western Quebec Paper Mills are erecting a plant at St. Andrews East which will have a capacity of 1,800 tons per year of light-weight papers, tissues, etc. The St. Regis Paper Company is developing a water-power site and building a mill at Godbout, Quebec. The American Perforated Wrapping Paper Company of Albany, New York, is building a mill at Sheet Harbour, Nova Scotia, with an annual capacity of 25,000 tons of pulp. The company has completed a contract with the Nova Scotia Power Commission for 6,000 hydro-electric horse-power and the commission is now installing a plant to supply it.

FUTURE POWER REQUIREMENTS OF THE INDUSTRY

With the rapid depletion of pulpwood supplies in the United States, Canada is being more and more depended upon to supply the demand for paper. With the constantly mounting cost of producing power from fuel it is apparent that power for the industry must continue to be obtained in ever growing proportions from water, and Canada is particularly favored in having her water-powers widely distributed among ample forests. As the consumption of pulpwood is rapidly increasing, it is apparent that settlement and water-power development will steadily extend northward. With the growth of population and the recession of the pulpwood supplies other uses for the power left available will be found and new developments completed farther north. Pulpwood and water-power are the chief factors in connection with future expansion and Table 8 shows the proportion of these resources available in each province of the Dominion. While in certain areas the application of reafforestation methods will have considerable effect on the future of the industry, from 30 to 100 years will elapse before their influence will be felt and in the meantime natural supplies will have to be depended on to meet the demand. While true conservation of water-power

consists in its fullest economic development, continuity of supply depends upon the maintenance of suitable forest cover on the drainage basins. This inter-relation of interest emphasizes the necessity of adequate protection of our forests from excessive cutting, fire, insect pests, and disease.

Table No. 6.—Character of Hydraulic Motive Power in Pulp and Paper Mills in each Province

Province	No. of Mills	Installed and Purchased Power—H.P.					
		Turbine Installation in the Industry			Purchased Hydro-Electric Power	Total Hydro-Electric Cols. 4—6	Total from all sources Cols. 5—6
		Direct Drive	Hydro-Electric Drive	Total			
1	2	3	4	5	6	7	8
British Columbia......	5	26,790	28,350	55,140	....	28,350	55,140
Ontario................	46	89,066	85,123	174,189	96.985	182,108	271,174
Quebec................	56	151,792	85,440	237,232	131,120	216,560	368,352
New Brunswick........	4	2,668	11.060	13,728	650	11,710	14,378
Nova Scotia...........	10	17,251	80	17,331	....	80	17,331
Canada........	121	287,567	210,053	497,620	228,755	438,808	726,375

Column 3 represents the installation which is used to drive the mill machinery, such as grinders, etc., directly from water-power.

Column 4 represents the installation also operated by pulp and paper organizations, but where the power is first converted into hydro-electric energy, and electric drive is used to operate all or a portion of the mill.

Column 5 is made up by adding columns 3 and 4 and represents the total water-power installation operated by the pulp and paper organizations themselves.

Column 6 represents the amount of electric energy derived from water-power and purchased from central electric stations for use in the pulp and paper industry.

Column 7 is made up by adding columns 4 and 6 and is an indication of the use of electrical energy derived from water-power in the pulp and paper industry.

Column 8 gives the totals of columns 5 and 6 and indicates the total installation and purchased power for the industry derived directly or indirectly from water-power.

Table No. 7.—Hydraulic Power in Pulp and Paper Mills—Characteristics of Various Groups

Groups	Number of Mills in Group	Power—H.P.				Average Daily Producing Capacity per Mill in Group—Tons		
		Own Turbine Instal-lation	Pur-chased Hydro-Electric	Total for Group	Total per Mill in Group	Pulp	Paper	
							News	Others
1	2	3	4	5	6	7	8	9
British Columbia.......	5	55,140	....	55,140	11,030	164	105	10
Northern and Western Ontario...............	10	84,200	25,600	109,800	10,980	147	77	8
North Lake Huron......	3	48,810	11,000	59,810	19,940	314	197	....
Niagara and Toronto District...............	19	7,078	46,003	53,081	2,795	56	18	24
Eastern Ontario..........	14	34,101	14,382	48,483	3,465	40	10	20
Montreal District and Western Quebec.......	16	35,978	5,285	41,263	2.580	28	5	17
Eastern Townships......	6	30,852	9,100	39,952	6,660	92	13	9
St. Maurice Valley and Three Rivers District.	6	22,310	99,000	121,310	20,220	316	153	21
Quebec City District....	15	16,352	9.260	25,612	1,710	15	10	7
Lake St. John and Saguenay District.....	7	99.120	8,475	107,595	15,370	176	39	10
Lower St. Lawrence and Gulf.................	6	32,620	....	32,620	5.435	72	....	....
New Brunswick.........	4	13,728	650	14,378	3,595	82	15	....
Nova Scotia............	10	17,331	....	17,331	1,735	19	5	....

Note.—The large capacity of mills predominating in certain districts is emphasized by the figures under Column 6, while the class of production characterizing each group can be judged by the figures under Columns 7, 8 and 9.

The Utilization of Water-Power in Relation to Coal Production, Importation and Consumption

The great majority of all the cities and towns of Canada are dependent upon water-power for light, power, street railways, and in many cases for water-supply, and this situation means that the present social, business and manufacturing life of Canada and its future growth are intimately dependent on our water-power and its further development.

It is however in the achieved result of actual saving in coal consumption and in coal importation, that the benefit of water-power development to the country can be more definitely and strikingly demonstrated than by any other means. The Dominion Water-Power and Reclamation Service has reviewed this aspect of the situation in an exhaustive manner on several past occasions and it is the intention to briefly summarize in this report the more recent statistics and the conclusions that may be drawn therefrom.

In particular there will be explained the annual coal equivalent of developed water-power, i.e. the tons of coal replaced by each horse-power of water-power in use; the coal consumption and imports by provinces and the corresponding water-power resources and development; the coal necessities of Canada's "Acute Fuel Area" and how enormously these necessities have been diminished by water-power development; the strikingly smaller coal consumption per capita in Canada than in the United States in spite of our colder climate; the proportion of water-power and fuel-power in use, and other related points.

Any such examination establishes indisputably two main points: (1) that the development of water-power constitutes the only real and large relief yet achieved in the fuel problem within the acute fuel area and (2) that it is our water-power resources and the low average cost of power therefrom that has made possible such rapid development of our manufacturing industries, that the net value of product of our factories (deducting duplication) is now greater than that of agriculture.

RELATION OF WATER-POWER TO COAL

The advantages of water-power may be briefly summarized thus:—

1. It is a native raw material and industry.
2. It is a non-depletable and inexhaustible source of power and heat.
3. It offers proved certainty as to practical application and financial success.
4. It is the source of power requiring the minimum of labour and therefore giving the maximum security against labour troubles.
5. It gives the maximum relief to transportation.
6. With a few local exceptions it is by far the cheapest power available.

Extent of Resources.—The continuous 24-hour power capacity available at minimum stream-flow is over 18,000,000 horse-power. In practice, power is rarely used continuously, and the actual capacity is therefore considerably greater. The commercial capacity is estimated at over 32,000,000 horse-power and this would correspond on the basis of present installations to nearly 42,000,000 turbine horse-power installed.

Extent of Present Development.—The turbine horse-power installed as at January 1, 1924, was over 3,227,000 horse-power and this represents, with transmission and distribution, a capital investment of over $687,000,000.

COAL EQUIVALENT OF DEVELOPED WATER-POWER

This is an important point in the matter of the relation of water-power to the coal problem and has received very full study. It may be arrived at by two distinct methods: (1) on the basis of the average coal used per horse-power per hour in steam plants, and (2) by analysis of official statistics of coal consumption, population, and use of coal in industries.

These two methods give closely similar results, i.e., 9 tons of coal per annum per horse-power installed.

COAL CONSUMPTION AND IMPORTS IN RELATION TO WATER-POWER

The total coal consumption in 1923 is the highest on record. However, the consumption in 1922 was the lowest since 1916, due to the shortage of coal caused by the United States strike, and supplies were only maintained by serious depletion of the reserve stocks of dealers, railroads, public utilities, institutions, etc.—the marked rise in 1923 therefore does not represent any special increase in consumption but is probably mainly a renewal of reserve stocks, with in many cases increased reserve against future risks.

The present position may be shown in figures comparing the average coal consumption and imports during the past five years with the coal equivalent of the present water-power development in tons and value per annum.

Coal—	
Average annual consumption, 1919–1923	32,147,000 tons
Average annual imports, 1919–1923	17,577,000 "
Water-power—	
Installed H.P. Jan. 1, 1924	3,227 000
Coal equivalent in tons per annum	29 000.000
Coal, value at $10 per ton	$290,000,000

With normal increases in all respects along the lines shown by results over the last fifteen years the coal equivalent of developed water-power will equal the total coal consumption about the year 1927—in other words by 1927 Canada will be using only half the coal she would have required if there had been no water-power development.

COAL OUTPUT IN RELATION TO WATER-POWER

It is of interest to consider what degree of relief has been given to the coal situation during the last decade by native coal and by water-power respectively, as shown in the following table:—

Coal Output and Water-Power Development—Comparison of Increases

—	Coal Output Tons	Water-Power	
		Installed Turbine H.P.	Coal Equivalent in Tons
1910	12,909,000	965,000	8,700,000
1911	11,323,000	1,348,000	12,100,000
1912	14,513,000	1,467,000	13,200,000
1913	15,012,000	1,674,000	15,050,000
1914	13,638,000	1,936,000	17,400,000
1915	13,267,000	2,078,000	18,700,000
1916	14,483,000	2,194,000	19,760,000
1917	14,047,000	2,260,000	20,350,000
1918	14,978,000	2,352,000	21,200,000
1919	13,919,000	2.444,000	22,000,000
1920	16,947,000	2,482,000	22,360.000
1921	15.057,000	2,680,000	24,100,000
1922	15,157,000	2,974,000	26,750,000
1923	16,984.000	3,227,000	29,000,000
Increase per cent	31·5%	235%	235%

It will be seen that, from 1910 to 1923, while the production of native coal has only increased 31.5 per cent, the coal made unnecessary by water-power has increased 235 per cent.

In terms of production per head of population, the coal output over that period has been stationary, but the water-power development and coal thereby replaced has increased 157 per cent.

In the shorter period since 1920, in spite of the shortage and high prices of imported coal, the coal output has made practically no increase, but the water-power development and coal thereby replaced has increased 28 per cent in the same three years.

It will also be seen that while the coal equivalent of water-power was 33 per cent below the coal output in 1910, by 1923 it had become over 70 per cent greater than the output.

A study of the foregoing will show clearly how little our own coal resources have done over this long period towards the relief of coal importation compared with the direct saving due to water-power development.

THE ACUTE FUEL AREA

The foregoing statistics apply to the Dominion as a whole but the relief afforded to the coal situation by water-power development is even more striking when the acute fuel area is considered separately. It is now agreed that this term can only be applied to Ontario and Quebec and that it is the supply of coal to these provinces that constitutes the "fuel problem of Canada." For the moment they may be considered as a unit.

Ontario and Quebec contain over 60 per cent of the total population of Canada and nearly 80 per cent of the total manufacturing development. They use over 60 per cent of the total coal consumption of the Dominion and 93 per cent of their combined coal consumption is imported from abroad.

In water-power these provinces have between 12 and 18 million horse-power available and of this over 2,563,000 horse-power is already developed, this developed water-power represents an increase of 215 per cent since 1910.

The combined coal consumption of Ontario and Quebec for 1923 was 23,810,000 tons. The coal equivalent of developed water-power in the same area is over 23,000,000 tons. It will therefore be seen that but for this developed water-power, Ontario and Quebec would require about twice their present supply of coal.

It may however be pointed out that had these great industrial provinces been dependent on imported coal for their manufacturing power they could never have attained their present commercial development.

COAL CONSUMPTION PER CAPITA—CANADA AND UNITED STATES

The average coal consumption per capita for all uses of coal from 1918 to 1922 inclusive, on exactly the same basis for each country, was, United States 5.11 tons, Canada 3.65 tons, or 29 per cent less in Canada than in the United States.

In view of the colder average climate of Canada the opposite result might be expected. Analysis shows that this lower consumption in Canada is directly due to the much greater use of water-power in industry, as shown in the following paragraphs.

USES OF COAL AND POWER

Uses of Coal.—The United States superpower survey found as the result of an exhaustive study that of all the coal used in the United States approximately one-half was used for producing power and one-half for producing heat but that in producing power only about 5 per cent of the total energy in the coal is utilized while in producing heat about 50 per cent is utilized. The great saving in coal by the use of water-power is therefore in producing power, not heat.

Uses of Coal in Per Cent of Total Consumption

—	Canada	United States
	1921	1920
	Per cent	Per cent
Steam railways	29	27
Bunker coal	4	2
Industries and coke	34	49
Electric light and power	2	3
Domestic use and gas making	31	19
	100	100

It will be seen that the proportion used for domestic consumption is much higher in Canada and that the proportion used for railroads is also higher in Canada—the latter might be expected since the population per mile of track is only one-half of that in the United States.

For industries Canada uses 34 per cent and the United States 49 per cent of the respective total consumption. This is not 15 per cent difference—it is a difference of 15 in 49 or 31 per cent, so that proportionately Canada uses 31 per cent less of her coal in industry than does the United States.

It naturally occurs to one that this may be due to a greater degree of industrialism in the United States than in Canada, however, investigation shows that on a per capita basis Canada is nearly on a par industrially with the United States and this fails to account for more than a small portion of the large difference.

It appears therefore that the use of coal for domestic purposes (which is comparatively little affected by water-power) and for steam railways (so far very slightly affected by water-power) is relatively greater in Canada than in the United States, but that the use of coal for industries is relatively some 31 per cent less in Canada than in the United States.

These conditions are fully accounted for by the greater development of water-power in Canada than in the United States, as follows:—

The hydraulic horse-power installed per 1,000 of the population is over 350 in Canada to about 100 in the United States or $3\frac{1}{2}$ times as much. Of all the primary power in use in Canada (excluding steam railroads) 70 per cent is supplied by water-power, 30 per cent by fuel power; in the United States the position is more than reversed.

Uses of Power.—Power is used in Canada for different purposes in approximately the following proportions:—

Power for all purposes except railways	51%
Electric light and domestic use	9%
Electric railways	4%
Steam railroads. Estimated average H.P. actually used	36%
	100%

Proportions of Water and Fuel-Power.—These stand in Canada approximately thus:—

—	Including Railroads	Not Including Railroads
	Per cent	Per cent
Water-Power	45	70
Fuel Power	*55	30
	100	100

* The 55 per cent for fuel power divides into 19 per cent for industrial uses and 36 per cent for steam railroads.

WATER-POWER AND MANUFACTURING DEVELOPMENT

The great bulk of Canadian manufacturing takes place in the acute fuel area, Ontario and Quebec. As before pointed out the marked development achieved in manufacturing in recent years could not have taken place with the handicap of entire reliance on imported coal and this development in manufacturing bears striking evidence to the value of water-power to the country.

Population and Manufactures.—During the past decade, while the population of the Dominion increased 22 per cent, the use of water-power in industry increased 245 per cent and the capital invested in manufacturing 175 per cent.

Dependence of Industries on Water-Power.—Of the total output of Central Electric Stations 97 per cent is furnished by water-power. Of all the primary power in the Dominion, for all purposes except steam railroads, 70 per cent is furnished by water-power.

THE REAL NATIONAL VALUE OF WATER-POWER

The value of water-power lies in its cheapness, not in a high selling value. For instance with wheat, lumber, pulp, etc., the higher the price the greater the "value of product" and the greater the value to the country on account of the large export trade, but with water-power the lower the price the greater is the assistance to a low cost of production in all other lines of manufacture, for both home consumption and export, and therefore the greater the benefit to the country.

A reasonable estimate of the national value of water-power is that it is at least the cost of coal to produce the same amount of power if the water-power had not been developed.

This, as before shown, is $290,000,000 per annum, practically all of which would have to be sent abroad annually if we had no water-power; pro-rata for 1930 it will be nearly $500,000,000.

THE EFFECT OF WATER-POWER ON FUTURE COAL CONSUMPTION

It has been shown that the total coal consumption of the Dominion is increasing but slowly, due to the rapidly increasing use of water-power in industry. The leading factors in the future may however be considered in a little more detail.

In manufacturing industry, as it develops, there must be increased use of coal for the manufacture of coke for metallurgical purposes and for process steam, but an increasing share of the power used and much of the process steam will be taken care of by water-power.

In the domestic field the amount of heat required for house-heating must increase with population and this cannot be supplied on any wholesale scale by water-power, nevertheless it appears probable that at the present cost of coal there will be appreciable development in the use of electricity for seasonal, off-peak and supplementary house-heating.

For steam railroads, which use nearly 30 per cent of the total coal consumption, the only relief is in electrification. While some local and inter-urban lines will probably be electrified in the near future, the commercial practicability is dependent on density of traffic and it does not appear probable that electrification of steam railroads on any large scale will take place for many years.

While the total coal consumption will vary from year to year, and will tend to average a continuous increase, there is no reason to expect any great increase so long as there is active development of water-power.

Water-Power in the Mining Industry

The recent revival of activity in the mining industry of Canada has stressed the necessity of ample supplies of power available at a cost that will permit of the production and treatment of large quantities of raw materials in the districts in which the mines occur. The extent to which this need has been met by the development of our advantageously located water-powers, has been made the subject of special study by the Dominion Water Power and Reclamation Service, a general resume of which is here given.

The theory is often advanced that Canada is likely to become the leading mineral producing country of the world, and considerable ground for this assumption is found in the fact that she contains 16 per cent of the world's known coal reserves, has greater asbestos, nickel, and cobalt deposits than any other country, and ranks third in the production of gold; while the diversity of her mineral endowment is indicated by the fact that the three main mineral divisions, metallic, non-metallic and structural and clay products include some 60 principal items, 17 of which each had, in 1923, a production value of $1,000,000 or over. These leading products are listed below in order of value, viz:—

1. Coal
2. Gold
3. Nickel
4. Portland Cement
5. Copper
6. Silver
7. Clay Products
8. Lead
9. Asbestos
10. Natural Gas
11. Stone
12. Zinc
13. Lime
14. Cobalt
15. Sand and Gravel
16. Gypsum
17. Salt

Figures of total production fail to convey the proper impression of the magnitude of the industry on account of the diversity of product and units involved, while the varying prices attendant on fluctuating market conditions make computations of value difficult. Probably the fairest conception of the value of the output may be arrived at by stating that the lowest value since 1910 was that for the year 1911, viz. $103,221,000, the highest that for 1920 when a value of $227,860,000 was reached, while the average annual value during the last five-year period, 1919 to 1923, amounted to $194,957,000. As commodity prices reached a peak in 1920, and have since receded, production computed in terms of value is not a fair basis for comparison. The Dominion Bureau of Statistics states that a weighted index showing the volume of production, would undoubtedly mark 1923 as the banner year in Canada's mineral industry. In that year new output records were established for coal, lead, zinc, asbestos, and for the value of cobalt.

THE RELATION OF POWER TO THE MINERAL INDUSTRIES

The principal uses of power in mining are for compressing air for drilling; driving motors or engines for hoisting; haulage of ore above and below ground; driving ore crushers and conveyors; pumping for water supply and for the removal of ground water; lighting; heating; ventilating; signalling; machine, blacksmith and framing shops; and for various electro-metallurgical processes. Even in the comparatively simple mining processes involved in the recovery of coal as much as 10 per cent of the product may be consumed in generating the power required. The following table shows the amount of power used in the principal divisions of the industry and the power in each division as at January 1, 1924:—

Total Power Used

—	Fuel Power H.P.	Water-Power Generated H.P.	Water-Power Purchased H.P.	Total Power H.P.	Per cent
Metal Mining	32,700	26,000	111,700	170,400	33·2
Coal Mining	160,900	15,300	15,000	191,200	37·2
Non-Metal Mining	29,500	1,100	62,200	92,800	18·1
Structural Material and Clay Products	12,800	2,000	44,300	59,100	11·5
Total	235,900	44,400	233,200	513,500	100·0

The relation of the primary power installed by the mining companies and the power purchased from central electric stations may be shown thus:—

Installed Power and Purchased Power

Primary Power Installed—			
Fuel-Power	235,900		
Water-Power	44,400		
		280,300	54·5%
Purchased power (all hydro-electric)		233,200	45·5%
		513,500 h.p.	100·0
Proportions of Water and Fuel-Power—			
Water-Power		277,600	54%
Fuel-Power		235,900	46%
		513,500 h.p.	100%
Proportions of Fuel-Power—			
Steam			96·3%
Gas			2·0%
Oil			1·7%
			100·0%

From the above it will be seen that over half a million horse-power is used in the industry and that of this 54 per cent is water-power, 44.6 per cent is steam power and 1.4 per cent is developed by internal combustion engines.

The Fortunate Relationship of Water-Power and Mining Districts.—From the point of view of minerals and the development of mining, Canada may be divided into five main areas:—(I) the Maritime Provinces, (II) Quebec, (III) Ontario, (IV) the Prairie Provinces and (V) British Columbia and the Yukon and each of these areas possesses large resources of water-power, developed or available for development, for mining. With the exception of some of the coal-fields of the central plains there is no mineralized area for which ample water-power cannot be made available. This is particularly the case in Ontario and Quebec, which being situated in the " acute fuel area " of Canada, would be almost entirely dependent upon coal imported from the United States were it not for hydraulic power.

From estimates made by the Dominion Water-Power and Reclamation Service, it is computated that at January 1, 1924, the hydraulic installation for mining purposes in Canada had reached a total of 277,600 horse-power of which 44,400 horse-power is installed by the mines themselves, while 233,200 horse-power is purchased from central electric stations. A conservative estimate of the capital investment necessary to develop this power is $74,000,000.

TYPICAL WATER-POWER INSTALLATIONS FOR MINING

Maritime Provinces.—Based upon value of production approximately 90 per cent of the mining carried on in the Maritime Provinces is for the recovery of coal and so far water-power has not been utilized here for this purpose,

although its satisfactory adaptation to coal mining in British Columbia and Alberta would indicate that a similar use here is only a matter of time. In Nova Scotia, however, there are hydro-electric developments operated by gold mining companies, their installations being 1,600 horse-power, 425 horse-power and 30 horse-power respectively. In addition considerable purchased power is used in the manufacture of cement and the mining of the various non-metallic minerals found.

Quebec.—Although the mineral output of the province of Quebec at the present time is mainly non-metallic, copper, gold, iron, lead, molybdenite, silver and zinc have all been mined during recent years; while within the last two years prospecting for gold, which has been carried on in Rouyn and adjoining townships in Temiskaming country, has led to important discoveries and the staking of large areas. The leading asbestos mines of the world are found in the southeastern portion of the province, 85 per cent of the world's supply being produced there. There is also a very extensive range of other non-metallic minerals, while the production of structural materials constitutes an important industry. Power for mining is practically entirely furnished by the central hydro-electric stations of the province. The Shawinigan Water & Power Company transmit large amounts of power from Shawinigan falls across the St. Lawrence river near the city of Three Rivers to the asbestos mines of the Eastern Townships. Power is also furnished to this field by the St. Francis Water-Power Company from their station on the St. Francis river. The Southern Canada Power Company supply a comparatively small amount of power for copper mining, while the large scale operations of the British American Nickel Company at Deschenes for the electrolytic reduction of nickel, receives power from the two developments of the Ottawa and Hull Power and Manufacturing Company at Hull. An additional source of power for the British America Company will be provided by the completion of the Calumet station of the Ottawa River Power Company, an associate of the Ottawa and Hull Power and Manufacturing Company, the transmission lines of the two companies connecting at Deschenes. The Portland cement industry and the production of brick, tile, and other structural materials also provide a considerable market for hydro-electric power.

Ontario.—Ontario ranks first among the provinces in diversity and value of mineral production and being, like Quebec, situated in the acute fuel area, depends almost entirely on the abundant supplies of hydraulic and hydro-electric energy which are, fortunately, available to every field. The major hydraulic developments in the province for mining are, of course, located in the gold, silver, and nickel areas of northern Ontario where over 107,000 horse-power are installed for this purpose, while several large additional installations are under construction or in active prospect. Much of this new equipment will be in operation before the end of the present year, and is expected to terminate the power shortage which has hampered production in the past.

The outstanding central electric station companies operating in the mining fields of Ontario are the Northern Ontario Light and Power Company with 20,420 horse-power installed in four hydro-electric stations and 5,500 horse-power in a hydro-compressed-air station in the Cobalt district and the Northern Canada Power Company operating two stations with a combined installation of 19,800 horse-power on the Mattagami river near Timmins. A subsidiary of the latter company, the Lower Sturgeon Power Company, has completed a 4,000-horsepower station on the Mattagami river in the Timmins district, while the parent company has a 20,000-horsepower station under construction on the Quinze river in western Quebec and has completed a transmission line therefrom to connect with their northern Ontario lines. The Great Northern Power Company completed a 4,000-horsepower station in 1923 on the Montreal river to serve this field and there are also a number of smaller stations distributing

power there. Further south in the nickel-copper area, the Wahnapitae Power Company have two stations on the Wanapitei river with a combined installation of 9,600 horse-power from which over 95 per cent of the output is sold for mining purposes. In the southern portions of the province production is limited to non-metallics and structural materials and here the demand is met by the extensive transmission systems of the Ontario Hydro-Electric Power Commission of Ontario.

Many of the mining companies have established hydraulic power stations and generate power to meet their own requirements. Chief among these are the International Nickel Company with 21,300 horse-power installed in two stations on the Spanish river; the Mond Nickel Company (Lorne Power Co.) with 9,600 horse-power, 4,800 horse-power at Nairn falls on the Spanish and 4,800 horse-power on the Vermilion river. This company intends adding 2,750 horse-power to their Nairn Fall's plant during the present season. The Hollinger Consolidated Gold Mines Ltd. are constructing a 24,000-horsepower plant on the Abitibi river to overcome a shortage of power which has, at times, considerably hampered their operations, and expect to commence development before the end of the present year.

The Prairie Provinces.—The Prairie Provinces are Manitoba, Saskatchewan, and Alberta. Manitoba possesses a comparatively small field of lignite coal. Saskatchewan possesses some 66,000 millions of tons of lignite and ranks third among the provinces of the Dominion in coal resources; while Alberta has semi-anthracite, bituminous, and lignite coals, constituting 88 per cent of the total coal resources of the country. These coal deposits have, in the past, as in Nova Scotia, been depended upon to provide power for the industry, but upon the completion of the East Kootenay Power Company's 15,000-horsepower station at Elko, British Columbia, a transmission line was constructed across the interprovincial boundary and many of the larger Alberta mines contracted for supplies of hydro-electric power. Among the mines which changed from steam to hydraulic power may be mentioned the West Canadian Collieries at Bellevue and Blairmore; International Coal and Coke Company at Coleman and the Hillcrest Collieries at Hillcrest.

British Columbia and the Yukon.—Water-power has been extensively developed for mining purposes in both British Columbia and the Yukon Territory, over 81,000 horse-power being installed for that purpose in British Columbia and 13,000 in the Yukon.

The large-scale operations for the production of zinc, copper and lead, carried on in the Kootenay district by the Consolidated Mining and Smelting Company of Canada Ltd., operating such well known mines as the Centre Star, Le Roi, War Eagle and Josie in West Kootenay, and the Sullivan mines at Kimberley in East Kootenay—are supplied with hydro-electric energy from two plants on the Kootenay river, with a total installation of 38,000 horsepower and one on the Cascade of 3,900 horse-power operated by a subsidiary of the mining company, the West Kootenay Power and Light Company Ltd. Power from these stations is transmitted over 450 miles of line to the various mines and so great is the demand that construction work is at present under way which will provide an additional 30,000 horse-power. Power for the Sullivan mines is being secured from the East Kootenay Power Company.

One of the most important coal mining areas in Canada is that of the Crowsnest Pass and Elk River district in east Kootenay and here recently completed hydro-electric developments are rapidly replacing coal as a source of power for mining. The East Kootenay Power Company operating a 7,500-horsepower hydro-electric station on Bull river and a 15,000-horsepower station near Elko, have completed contracts with many of the leading mines of the district, including the Crows Nest Pass Coal Company, Corbin Coal and Coke

Company and the McGillivray Creek Coal and Coke Company to supply power. On the Pacific coast the extensive copper and gold areas are supplied with power from a number of important developments. The Granby Consolidated Mining, Smelting & Power Company have two developments totalling 13,200 horse-power; the Britannia Beach Mining & Smelting Company two totalling 19,000 horse-power; the Hedley Gold Mining Company one of 1,600 horse-power; the Surf Inlet Company one of 1,200 horse-power, and there are a large number of smaller installations. Extensive coal mining operations conducted on Vancouver island by the Canadian Collieries Ltd. are supplied with power from a 12,000-horsepower hydro-electric plant operated by the company on Puntledge river, from whence power is transmitted to their mines.

In the Yukon Territory five water-power sites have been developed to supply power for mining, only two of which need be mentioned, viz. that of the New North West Corporation Ltd., with 10,000 horse-power and the Yukon Gold Co. with 3,180 horse-power.

RELATION OF POWER SUPPLY TO PRODUCTION

In every branch of the mining industry, from the preliminary drilling to the final refinement of the product, large amounts of power are necessary, and should be available as required, and when it is stated that in the comparatively simple mining operations involved in the recovery of coal as much as 10 per cent of the product may be used in developing the necessary power, the importance of low-priced power at once becomes apparent. In many cases large scale operations, which alone make the difference between profit and loss, are only made possible by abundant supplies of low-priced hydraulic power. Many mines on account of their geographical location would find the cost of rail haul on fuel or untreated ore prohibitive, but with hydraulic power profitable operation has been possible, and much low-grade material has been given commercial value. The fact that the coal mines, where possible, are abandoning pit-head power production, in the generation of electricity from fuel, in favour of hydro-electricity, is the strongest proof of the necessity of cheap power and that this is furnished by hydro-power.

AVAILABILITY OF WATER-POWER FOR UNEXPLOITED AREAS

The country extending from Labrador on the east, enclosing the Hudson Bay Basin, and referred to as the Laurentian Plateau region, consists of a huge U-shaped area of pre-Cambrian rocks, estimated to cover 2,000,000 equare miles, or over one-half of Canada. This region occupies nearly all but the most southerly portions of Quebec, Ontario, and Manitoba and as the pre-Cambrian rocks are remarkable for the variety of their mineral deposits, there is little doubt that the advance of settlement and prospecting will uncover deposits of great value. This would seem to be verified by the recent gold discoveries in Rouyn and adjacent townships in Quebec, and the Flin-Flon and Schist Lakes gold and copper-zinc-sulphide deposits in Manitoba. The Northwest Territories are also believed to possess great latent mineral resources. Those to which attention has already been directed include the native copper of the Coppermine River area, the iron ores of Belcher island, gold and zinc near Great Slave lake and petroleum in the Mackenzie River basin below Norman. A fortunate feature in connection with all these deposits is the availabilty of water-power for their development, the rugged character of the country containing the mineral deposits providing also for numerous falls in its rivers. Ample power for the development of the Rouyn district can be obtained from the numerous falls and rapids of the Quinze and upper Ottawa rivers, while the Flin-Flon—Schist Lake areas will be served by rivers adjacent thereto. It is stated that power for the Bingo mine near Herb lake is to be developed on the Grassy river during the present year.

Reference to Table No. 1, Available and Developed Water-Power, will show the fortunate distribution of water-power throughout Canada. The two provinces without native coal, Ontario and Quebec, lead in the possession and utilization of water-power, followed closely by Manitoba, where only lignite coal is found. So far as information is available, there is no prospective mineral area, with the exception of some of the coal-fields of the middle plains, where hydraulic energy cannot be made available.

Dominion Hydrometric Survey

The Dominion Hydrometric Survey embraces all the provinces of Canada. In the Prairie Provinces the work is a direct responsibility of the Federal Government and in the other provinces it is now carried on under co-operative agreements. With this consolidation of the hydrometric survey, it has been possible to rearrange both field activities and office administration and to standardize the methods. This has resulted in an overall saving in administration and a natural gain in efficiency, together with the valuable factor of making available to the public water-resources information at one central source. The arbitrary divisions of provincial boundaries have been eliminated and the logical and natural divisions of major drainage basins have been instituted. The main drainage basins into which the country has been divided together with the location of the district office or offices in charge are as follows:—Pacific drainage, Vancouver; Arctic and Western Hudson Bay drainage, Calgary and Winnipeg; St. Lawrence and Southern Hudson Bay drainage, Ottawa and Montreal; Atlantic drainage, Halifax.

A most pressing demand for detailed and extensive records of the regimen of the various lakes and rivers of the country has been brought about by the increasing utilization of water-resources for diversified and often conflicting purposes and particularly in connection with power development and irrigation projects. No greater recognition could be given to the importance of stream-flow records than in the material voluntary co-operation afforded the survey by numerous individuals and private co-operations.

RUN-OFF CONDITIONS IN CANADA

As shown in detail in the reports of the district chief engineers the average run-off for the year has been below normal in British Columbia, slightly above normal in Alberta, normal in Saskatchewan, slightly above normal in Manitoba and Ontario, and normal in Quebec and the Maritime Provinces. The distribution of run-off throughout the year was, however, at variance with average conditions; in certain parts of the country flood inflow exceeded the average, while run-off during the autumn was deficient.

In the Pacific drainage, stations typical of general run-off conditions indicated a run-off of 91 per cent of the average. Except on Seymour creek where the flood was 295 per cent of the average, and the deficiency 22 per cent of the average, no abnormal run-off conditions were recorded.

With the exception of the Assiniboine River basin, run-off in the Arctic and Western Hudson Bay drainage, ranged from 50 per cent to 135 per cent of normal. The run-off in the streams rising in the eastern slope of the Rocky mountains was above normal with the exception of the Peace river which had only 97 per cent of the average. In the Oldman tributary basin all the streams reached stages in excess of any previously recorded as did also the Highwood and Elbow rivers. The prairie streams in the northern part of the three provinces were all below normal as was the Red river in southeastern Manitoba. In the Assiniboine basin excessive spring floods were again recorded and the average for the year was 240 per cent of the mean of previous years. The run-off for Moosejaw creek was 8,500 per cent of the mean in the month of July.

In the St. Lawrence and Southern Hudson Bay drainage, the run-off of typical stations, ranges from 80 per cent to 115 per cent of the mean.

In the Atlantic drainage, comprising the Maritime Provinces, run-off conditions were exceptional. Typical stations show flood run-off ranging from 200 per cent to 265 per cent and low-water run-off as low as 20 per cent of the mean. The average run-off for the year was about normal.

POWER AND STORAGE INVESTIGATIONS

During the year the dictates of economy again necessitated the most careful apportionment of field expenditures and only the most urgent power and storage investigations were undertaken. Office studies of the developed and undeveloped water-power resources of the Dominion were, however, prosecuted with vigour, close co-operation being maintained with the provincial authorities of British Columbia, Ontario, Quebec, and the Maritime Provinces.

In British Columbia special investigations were continued in co-operation with the city of Vancouver in connection with the possibilities for hydro-electric development within a radius of 100 miles of that city. In co-operation with the Provincial Water Rights Branch the analysis of the water-power resources of the province was actively carried on.

In Alberta an application for power privileges on the Crowsnest river necessitated a field inspection of the site and power market from which a report was prepared. Studies were made of power possibilities and flood prevention on the Elbow river.

A survey was made of a small power site on a branch of Lee creek for which an application had been received. Responsibility for the operation of the Lake Minnewanka storage during the filling season was again assumed by the department with very satisfactory results to all concerned.

In Manitoba field observations were made of the excessive floods on the Assiniboine river during the months of April and May, also studies of the causes and effects of these floods. The analysis of the water-power resources of the Prairie Provinces was actively carried forward.

In Ontario at the request of the Lake of the Woods Control Board a reconnaissance survey was made of the power and storage possibilities of the International Boundary waters above Rainy lake. The analysis of the water-power possibilities of the province was continued in co-operation with the provincial authorities.

In Quebec the exchange of water-resources data with the provincial authorities was continued and the analysis of the developed and undeveloped powers of the province actively carried on.

In New Brunswick, in co-operation with the New Brunswick Electric Power Commission, a survey was made at Grand Falls on the St. John river to determine the flowage and pondage that will result from the proposed power dam. An investigation was made of the power possibilities of Goldsmith brook near St. Stephen. As a result of the extraordinary flood of May 1, special investigations were made on a number of streams; particular attention being paid to the St. Croix river.

In Nova Scotia surveys were made and reports prepared of the power possibilities of the St. Croix river, Wallace river, Salmon river, East River in Chester, and West River in Antigonish. Considerable attention was also given to problems arising from other projects of the Nova Scotia Power Commission, notably the development on East River Sheet Harbour.

FLOODED LAND CONTOURS

The establishment of boundaries of overflowed lands and lands required for flooding as they affect the administration of water-power was carried on throughout the year.

The principal work carried out under this section during the season of 1923 was the survey of Alouette lake in the province of British Columbia. The

proposal by the Burrard Power Company to construct a dam at the present outlet of Alouette lake and raise the water from elevation 438 to elevation 485 for the purpose of developing power by diversion of the water through a tunnel to Stave lake will flood a considerable area of Dominion lands. The survey was made for the purpose of locating and describing this area, and involved a traverse of the 441-foot contour, representing ordinary high-water mark, the 490-foot contour, representing the upper limit of the area required for flooding and the subdivision of the area comprised within these lines.

The subdivision was commenced at the northeast corner of section 4 in township 4, range 4, west of the 7th meridian, from which point the lines were projected north and east and closed on Bluff Point triangulation station on Stave lake. This survey comprised portions of township 4, range 4, west of 7th meridian; township 4, range 3, west of 7th meridian, and township 5, range 3, west of the 7th meridian, and was sufficiently extended to include the location of the damsite in section 9, township 4, range 4, west of the 7th meridian, tunnel site in sections 10 and 11, township 5, range 3, west of the 7th meridian, and the power-house site in section 11, township 5, range 3, west of the 7th meridian.

All traverse lines were run with a transit and chain, and elevations determined by means of the dumpy level. The contours were located by right angled offsets from the traverse lines. Elevations are referred to the Ruskin datum of the British Columbia Electric Railway Company.

The total length of section line surveyed amounted to 32.5 miles and of traverse lines 53.5 miles.

In addition to the above the survey that was commenced at the Lower Seven Sisters site on the Winnipeg river in 1922 was completed between the north boundary of sections 4 and 5 in township 14, range 11, E.P.M., and the east boundary of sections 27 and 34 in township 13, range 11, E.P.M.

A survey was also made of the land required for flooding on the NE. $\frac{1}{4}$ of section 34, township 15, range 11, E.P.M., in order that the remainder of the quarter-section might be released for sale.

(b) Field Reports

District of British Columbia

R. G. Swan, *District Chief Engineer*

During the fiscal year ending March 31, 1924, regular stream measurement investigatory operations of the Dominion Water Power and Reclamation Service in the province of British Columbia have been continued consistent with the terms of the co-operative agreement of August, 1913, between the Department of the Interior at Ottawa and the Provincial Government.

ORGANIZATION

For purpose of administration and convenience of field operations the work in British Columbia is divided into districts, and is directed from the head office at 119 Pender street west, Vancouver, with a branch office at Kamloops. While the primary function of this British Columbia organization is to collect and tabulate stream-flow data for purposes of power development, irrigation, reclamation, and domestic water supply, the services of the engineers of this staff are frequently utilized in connection with investigations which require hydraulic engineering experience for other Dominion Government departments which have no engineers in the province. The greatest amount of such work is that performed for the Department of Indian Affairs in connection with the investigation of water rights, as well as for the installation of irrigation and water supply systems on Indian reserves throughout the whole of British Colum-

bia. During the past year, at least one engineering party has been maintained continuously in the field and one engineer has devoted his whole time to the adjustment of Indian water rights before the Provincial Board of Adjudication under the British Columbia Water Act.

CO-OPERATION

As already indicated, all hydrometric studies in British Columbia are made by this service under a co-operative agreement with the Provincial Government. All stream-flow data supplied at least annually to the Comptroller of Water Rights at Victoria.

Stations have been maintained on the Columbia, Pend-d'Oreille, and Okanagan rivers which are very important international streams, in co-operation with the Water Resources Branch of the United States Geological Survey. A considerable amount of work has also been done on international streams in conjunction with the Columbia Basin Survey Commission, which is investigating the irrigation possibilities in the Big Bend country in the Columbia River drainage.

Extensive hydrometric investigations have been carried on in co-operation with the city of Vancouver which is investigating the possibility of a hydro-electric development within a radius of 100 miles of the city. In all, some fifteen stations have been or will be established in connection with this work. All expenses in connection with the establishment of these stations including payment of gauge readers are being borne by the city of Vancouver.

Continuing the co-operation with the Department of Indian Affairs, good progress has been made toward the final settlement of Indian water claims, and many applications have been filed for additional rights to benefit the reserves in the interior of the province. Inspections and surveys in connection with the utilization of water under these rights, either by improvement to existing systems or under new projects, have received particular attention.

During the year ending March 31, 1924, ninety-four conditional licenses appurtenant to Indian Reserves were issued. Of this number, seventy-four were in confirmation of claims to water rights, under Board orders, and the remainder were issued by the comptroller under new applications, as follows:—

Agency	Under Board Orders	Under Applications	Total
Lytton	59	2	61
Kamloops	6	12	18
Okanagan	....	6	6
Kootenay	9	....	9
Totals	74	20	94

New applications for licenses, filed during the same period, totalled twenty-two. Of this number, thirteen have been granted, and nine are pending, as shown hereunder:—

Agency	Number Filed	Number Granted	Number Pending
Lytton	2	2	....
Kamloops	14	11	3
Okanagan	3	....	3
Williams Lake	1	....	1
Vancouver	1	....	1
Nass	1	....	1
Totals	22	13	9

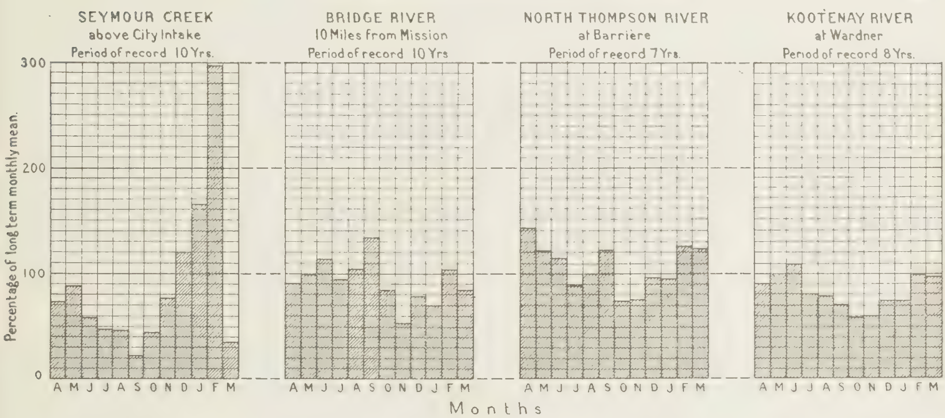
HYDROMETRIC SURVEYS

During the year ending March 31, 1924, 187 regular gauging stations were maintained on rivers and tributaries in the following main watersheds—Columbia, Fraser, Kettle, Kootenay, North Thompson, Okanagan, Pacific Coast (Mainland), Similkameen, South Thompson, Thompson, Lillooet, and Vancouver Island. Many of these stations were maintained for more than one purpose; 47 stations were maintained for power, 138 for irrigation, 6 for drainage and reclamation, 7 for domestic water supply, 7 for flood purposes, 5 for navigation, 6 for international problems, and 6 for statistical purposes. There were 21 new stations established and one station discontinued. Most of the new stations were established at the request of the Provincial Water Rights Branch in connection with water-power investigations along the Pacific coast, and irrigation problems on contentious streams in the arid district in the interior of the province.

PLATE 2

MEAN MONTHLY RUNOFF OF TYPICAL WATERSHEDS IN BRITISH COLUMBIA FOR YEAR 1923-24

RUNOFF SHOWN AS PERCENTAGE OF LONG TERM MONTHLY MEAN



The total run-off for the year ending March 31, 1924, was considerably below normal. The following are four typical gauging stations in the Pacific drainage, viz.—Seymour creek, near Vancouver, Bridge river, North Thompson river at Barriere, and the Kootenay river at Wardner. (See Plate 2).

In the Coast area, as typified by Seymour creek which has a drainage area of 69 square miles, low precipitation and run-off were recorded, the former being 92 per cent of the long-term mean and the latter 89 per cent. Flood run-off reached a maximum daily mean discharge of 177 second-feet per square mile in February as compared with the maximum daily mean of 245 second-feet per square mile in October, 1921. During this flood of 1921 a peak of 336 second-feet per square mile was reached. The low run-off occuring in September was at the rate of 0·52 second-foot per square mile the minimum discharge recorded for the past nine years.

In the Central Fraser basin, as typified by Bridge river which has a drainage area of 1,900 square miles, a precipitation slightly above average was recorded while the run-off was below normal, the former being 106 per cent of the long-term means and the latter 93 per cent. The flood run-off reached a maximum daily mean discharge of 8·32 second-feet per square mile in June as compared with a maximum daily mean of 13·7 second-feet per square mile in June, 1918. The low run-off, occuring in December, was at the rate of 0·211

second-foot per square mile as compared with the minimum daily mean of 0·189 second-foot per square mile in November, 1918, the minimum discharge recorded for the past nine years.

In the North Thompson River basin, as typified by the North Thompson river at Barriere which has a drainage area of 7,000 square miles, precipitation and run-off slightly above normal was recorded. The former being 119 per cent of the long-term mean and the latter 106 per cent. The flood run-off was not high, only reaching a maximum daily mean discharge of 8·98 second-feet per square mile in June as compared with a maximum daily mean of 11·15 second-feet per square mile in June, 1921. The low run-off, occuring in April, was at the rate of 0·383 second-foot per square mile as compared with 0·214 second-foot in March, 1919, the minimum discharge recorded for the past seven years.

In the Upper Kootenay basin, as typified by Kootenay river at Wardner which has a drainage area of 5,200 square miles, low precipitation and run-off were recorded, the former being 91 per cent of the long-term mean and the latter 83 per cent. The flood run-off reached a maximum daily mean discharge of 8·07 second-feet per square mile in June as compared with a maximum daily mean of 13·0 second-feet per square mile in June, 1916. The low run-off occurring in March was at the rate of 0.24 second-foot per square mile as compared with 0.12 second-foot in January, 1914 the minimum discharge recorded for the past ten years.

SPECIAL INVESTIGATIONS

Special investigations, in co-operation with the city of Vancouver, into the possibilities for hydro-electric development within a radius of 100 miles of the city of Vancouver, have been continued during the past year. In addition to streams already being investigated, new stations have been established on the following streams, Chilliwack at Chilliwack lake, Squamish river, Cheakamus at Cheakamus lake, Stony creek, Six Mile creek and Soo river. All capital expenditure has been borne by the city.

A hearing on the application of the Burrard Power Company to change their point of diversion authorized under Conditional License No. 6406 for the use of water out of Alouette lake, was held at the office of the Provincial Comptroller of Water Rights in Victoria on November 13. At that meeting it was decided to grant the change of point of diversion and permit the company to proceed with its surveys. Further hearings were held in January and February when objections to the application were considered. Mr. Walmsley, Crown Timber Agent, New Westminster, B.C., and Mr. Webb of this service, represented the Department of the Interior at these hearings. After several meetings an amicable settlement was reached and final approval of plans given by the Comptroller on February 26, 1924.

The city of Vancouver and surrounding municipalities have been making special studies of the run-off from the north shore streams, viz., Seymour and Capilano creeks. These investigations are to determine the proper course of development to ensure for the whole of greater Vancouver a satisfactory water supply, both for their present and future requirements. This service has investigated thoroughly the run-off conditions on these streams and all data have been supplied to the interested parties.

The study of the spring flood in the Crowsnest district was made during the past summer. Many streams in this district reached a stage never before recorded.

Engineers of this service made special velocity measurements in the Second Narrows on different tides to determine the velocities which may be encountered during construction of piers for the Second Narrows bridge across Burrard inlet at Vancouver.

SPECIAL INVESTIGATIONS—DEPARTMENT OF INDIAN AFFAIRS

Forty-two investigations were made during the year for the Department of Indian Affairs. These investigations covered a wide range in engineering including reports on water-storage, irrigation, domestic water supply, sewage disposal, and electric lighting for Indian industrial schools and Indian reserves. By agencies these investigations were made as follows,—Lytton 4, Kamloops 8, Okanagan 13, Williams Lake 5, Vancouver 4, Kootenay 2, Kwawkewlth 1, Bella Coola 1, Nass 1, and New Westminster 3.

When required, plans and specifications have been submitted to Ottawa covering all proposed works. Considerable construction work resulting from these investigations has been carried out during the year, most notable of which was the installation of a water-supply system at Metlakatla Indian village. This supply was brought a distance of one and one-half miles to the village, ensuring an excellent supply of water for both domestic use and fire protection. A smaller water-supply system was installed at Church House.

In conjunction with other water-users in that drainage, an impounding dam was built at Mamette lake which has greatly added to the possibilities for increased cultivation on the Nicola Mameet Indian reserve and various ranches and estates in the Guichon Creek valley.

In addition to the usual requests for hydrometric records for all purposes and from many directions, it is of interest to note that the Provincial Public Works Department have utilized our records more during the past year in connection with the design of road bridges throughout the province, than ever before. Our records now cover a period of years which make them valuable in connection with this work.

District of Alberta and Saskatchewan

A. L. Ford, *District Chief Engineer*

The regular stream measurement and power investigatory operations of the Dominion Water Power and Reclamation Service have been continued in Alberta and Saskatchewan during the fiscal year ending March 31, 1924.

The proprietary interest in the water resources of this area being with the Dominion, it devolves upon this Government to carry out investigations which will ensure the proper administration and utilization of these resources. The area covered by this district office comprises the Peace River block in British Columbia, the province of Alberta and the province of Saskatchewan except the Churchill River area in the northern part of the latter province which is tributary to northern Manitoba and therefore more accessible to the Manitoba organization of the service.

ORGANIZATION

The stream measurement operations in this area were begun in 1894 by the Canadian Irrigation Surveys, and these were carried out on a small scale until 1909, when it was decided to extend these operations and place them under an organization known as the Hydrometric Survey of the Forestry and Irrigation Branch of the department. From 1911 to 1920 the work was a portion of the operations of the Irrigation Branch or Reclamation Service. On July 1, 1920, the Dominion Water Power Branch took over the functions and staff of the Hydrometric Survey combining this work with that of investigatory power studies which it had for several years carried on in these two provinces. In 1923 the amalgamation of the Reclamation Service and Dominion Water Power Branch resulted in the combining in these provinces of the various functions and staffs of these branches.

The stream measurement operations are controlled from the district office in the Southam Building, Calgary and embrace practically the whole of the

provinces of Alberta and Saskatchewan. The large area covered necessitates engineers being placed in the field in charge of various sub-districts and their work requires continual supervision from the district office. For this reason the work of the district office at Calgary is divided into two divisions, namely, Northern and Southern, each of which is in charge of a division hydrometric engineer. The hydrometric field staff is also utilized for such other duties as may arise, as for instance, water-power investigations, and in many cases the engineer already in the field in connection with hydrometric duties can with little extra expense carry out investigations in the area he ordinarily covers.

CO-OPERATION

Under the arrangement made between the Dominion Water Power Branch and the Reclamation Service at the time of the transfer of hydrometric activities in 1920, and later through the amalgamation, all data of a hydrometric nature which the Reclamation Service required were obtained and made available. This work included beside basic hydrometric data, special investigations of the absorption losses in reservoirs and canal systems. The annual investigation of snow and ground-water conditions of the headwaters of the St. Mary river, instituted at the request of the Reclamation Service in 1922, was continued in May last. The results obtained were encouraging and it is probable that with each succeeding year they will become quite valuable. This survey is carried out in co-operation with the United States Geological Survey, and the data obtained are of special value to the United States Reclamation Service and the Alberta Railway & Irrigation Company, who are the chief users of water from this stream.

In connection with the problem of the International Joint Commission in dividing the waters of the Milk and St. Mary rivers, there has been carried out considerable hydrometric work, both routine and such special investigations of stream diversions and losses as were required by the commission. Co-operation has been continued with the Montana Division of the United States Geological Survey and the United States Reclamation Service in the measurement and apportionment of international waters along the boundary between Alberta and Montana, and Saskatchewan and Montana.

The investigations of canal and reservoir losses, carried out on various irrigation projects of the Canadian Pacific Railway's Department of Natural Resources as well as the ordinary routine measurement of diversions, have enabled the fullest co-operation to be maintained between our engineers and those of the company with beneficial results to both organizations. In connection with the investigation of canal and reservoir losses on the Canada Land & Irrigation Company's system the fullest co-operation was maintained with the engineers of the company.

The inspection of meteorological stations undertaken some years ago at the request of the Director of the Meteorological Service was continued. This work is done at little or no expense and without doubt is of value to the Meteorological Service.

At the request of the Universities of Alberta and Saskatchewan, field demonstrations of hydrometric methods were given for the students. In addition, lectures on hydrometric and water-power engineering were given at both unversities.

THE HYDROMETRIC SURVEY

During the fiscal year a total of 340 gauging stations were maintained on streams, canals, ditches, and lakes in the following main watersheds: Athabaska, Battle Creek, Belly, Bow, Frenchman, Little Bow, Lodge Creek, Milk, North Saskatchewan, Oldman, Peace, Qu'Appelle, Red Deer, Rock Creek, Ross Creek, St. Mary, Saskatchewan, Sevenpersons Creek, Souris, South Sas-

katchewan, Swiftcurrent Creek, and Waterton. Of the above, 8 were maintained on streams and 1 on a lake throughout the year for power purposes. For irrigation purposes 12 stations on streams were maintained throughout the year, and 54 stations on streams and 12 on lakes or reservoirs were maintained during open water only. In addition, 164 stations were maintained during the irrigation season on canals and ditches. One station on a stream and 2 on lakes were maintained throughout the year, and 13 on streams, 7 on lakes and 2 on canals were maintained during the open-water season for drainage purposes. In connection with domestic water supply problems 3 stations on streams were maintained throughout the year, and 5 on streams during open-water only. Two stations were maintained during the flood danger period for flood warning purposes. In connection with the International Waterways Treaty 4 stations on streams were maintained throughout the year, and 13 on streams, 18 on canals and ditches and 1 on a reservoir were maintained during open water only. Stations were also maintained at eighteen points for statistical purposes.

The year 1923-24 was noted for the number of storms and the heavy precipitation throughout the southern parts of both provinces. These storms were not particularly heavy in the northern parts of the territory, but in that area there was at least a normal precipitation. The heavy rains caused flood run-offs in many parts of Alberta and Saskatchewan, and it is interesting to note that some of these floods occurred as early as May 30 and 31, which is unusual for streams rising from the eastern slope of the Rockies. These summer rains followed several years of unusually low precipitation and run-off, which culminated in a winter where the flow from a number of springs ceased, or almost ceased and in many streams was the lowest on record. Although the summer run-off of southern streams was well above average, the autumn and winter flows are in general about normal, and this with a review of general run-off conditions would indicate that the ground-water table, lowered by the several years of drought, has not yet returned to normal. An exceptionally fine fall free from precipitation and a very mild winter no doubt assisted in producing this condition.

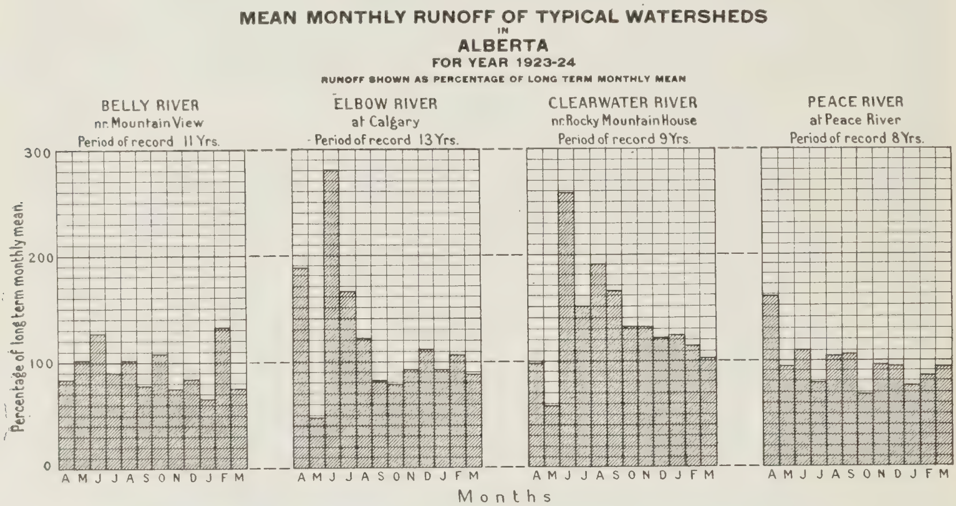
The streams for which graphs are shown (see Plates 3 and 4) and which are considered typical of various areas are: For southern Alberta, the Belly river near Mountain View; for south central Alberta, the Elbow river at Calgary; for north central Alberta, the Clearwater river near Rocky Mountain House; and for northern Alberta, the Peace river at Peace River. In Saskatchewan the southwestern or Cypress Hills area is shown by Battle creek at Tenmile; the southeastern part by Moosejaw creek; the central northeastern part by Carrot river; and the central northwestern part by Battle river near Battleford.

In southern Alberta the average run-off was high and the typical stations show from 102 per cent for the Belly to 144 per cent of the mean of the long term average for the Elbow. Flood stages occurred in the Oldman and Bow basins and new maximums were recorded at almost all stations. These run-offs reached a rate of 30.5 second-feet per square mile for the Elbow at Calgary and 35.2 second-feet per square mile for the Oldman at Macleod. In northern Alberta the run-off varied from 160 per cent on the Clearwater to 97 per cent on the Peace. Precipitation in Alberta varied from 86 to 100 per cent of average in the south to 154 per cent in central Alberta and 98 per cent in the north.

The Saskatchewan stations indicate that, except in the southeastern portion of the province, the run-off was much below the long-term average. The southwestern portion as typified by Battle creek had a run-off of 57 per cent, while Battle river indicates a run-off of 21 per cent for the central northwestern portion of the province, and Carrot river indicates 33 per cent for the central northeastern portion. In southeastern Saskatchewan run-offs were above

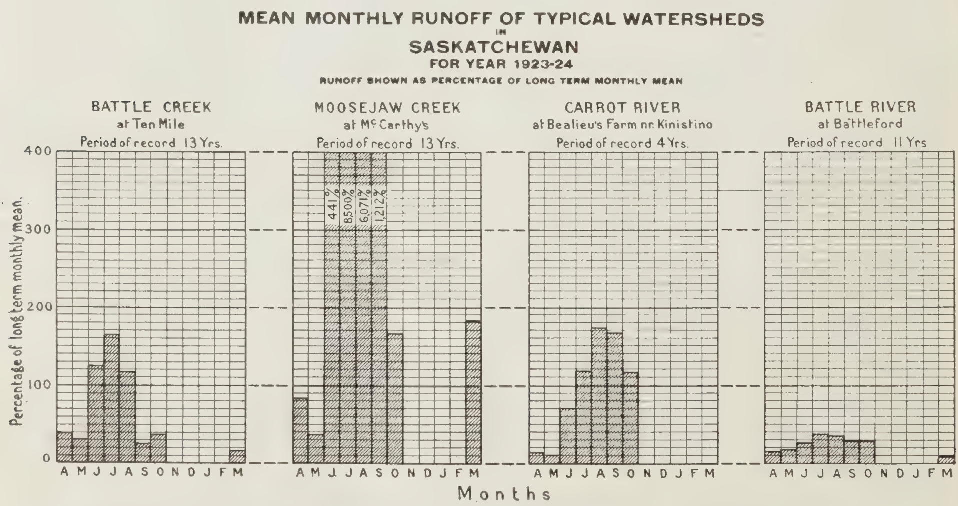
average as shown by Moosejaw creek with 253 per cent. Precipitation in Saskatchewan varied from 98 per cent to 108 per cent in the south to from 92 to 108 per cent of the average in the northern central part of the province. No abnormal run-offs occurred in Saskatchewan except on the South Saskatchewan river where the floods on the upper tributaries of this stream caused a maximum rate at Saskatoon of 2.6 second-feet per square mile.

PLATE 3



The current-meters used by this service and by many other users of meters throughout the country are rated at Calgary, Alberta, where the Dominion Water Power and Reclamation Service operates the only station of this kind

PLATE 4



in Canada. The repairing of current-meters is a point of some importance and one which is assuming considerable proportions. As it is generally necessary to re-rate a meter after repair the carrying out of repair work for the Service at the Calgary rating station is both an economy and tends to greater efficiency

as all instruments when returned to the various district offices are then in first-class shape and are accompanied by rating tables governing the instrument in its repaired condition. In addition, tables showing the rating of the instrument as received and before repair are usually prepared so that recent measurements may if necessary be corrected. During the fiscal year the station was operated from May 10 to November 15, when 100 current-meters were rated, 136 ratings made and 47 instruments repaired. Of the above, 8 meters were rated for the Water Rights Branch of British Columbia, 1 for the Canada Land & Irrigation Company, 5 for the Canadian Pacific Railway Company, 1 for R. S. & W. S. Lea of Montreal, 1 for the Sydney E. Junkins Company of British Columbia, 1 for the Lower St. Lawrence River Power Company of Quebec, and the balance for the various offices of this service as follows: Maritime Provinces 3, Quebec 4, Ontario 18, Manitoba 7, Alberta and Saskatchewan 40, and British Columbia 11. In addition, meters were rated and reports prepared in connection with special experimental tests on a new type of current-meter and on new patterns of meter weights.

SPECIAL INVESTIGATIONS

The East Kootenay Power Company, which is an extensive exporter of power from southeastern British Columbia to the coal companies of Crowsnest area of Alberta made application for the right to develop power at Crowsnest falls (sec. 28, tp. 7, rge. 8, W. of the 5th meridian). As a previous application for this site by the Christian Community of Universal Brotherhood of Alberta was under review an inspection of the site and field examination of the power market in the area was made.

Looking to a solution of the power and flood conditions in Calgary, the municipal authorities made application to develop the power and storage possibilities of the Elbow river in the vicinity of Canyon creek (tp. 22, rge. 6, W. of the 5th meridian). Data as to the power possibilities based on surveys made some years ago, and the latest records of flow were supplied to the city authorities, but no further action has as yet been taken by the city.

Application for the development of power on a stream flowing into lake Athabaska, Saskatchewan, was received and the applicants were requested to supply further information in connection with their proposals, but to date this further information has not been forthcoming. An application to divert water for power purposes from a branch of Lee creek (sec. 28, tp. 1, rge. 27, W. of the 4th meridian) was also received. A survey of this scheme was made and plans are at present in course of preparation.

Looking to the development of a provincial hydro-electric system, the Province of Alberta made application for a permit to divert water from Spray lakes with the object of developing power. This application and the one previously made for this site by the Montreal Engineering Corporation were still under consideration at the end of the fiscal year.

The operation of Lake Minnewanka reservoir of the Calgary Power Company during the filling season was again assumed by this service and the lake was brought to upper storage level by the opening of the tourist season. Exceptional run-offs resulted in the lake being above the upper level for a few days in June but prompt action materially assisted in maintaining a level below the danger point, and no damage to roads or buildings in Minnewanka townsite or elsewhere resulted. Additional precautions were also necessary during the season so as not to damage works under construction by the Dominion Parks Branch just below the dam.

During the fiscal year the agreement between the Calgary Power Company and the city of Calgary for the supply of hydro-power to the municipality terminated and a new agreement for a further period of five years under slightly different conditions was made. Under the new agreement the city

has been enabled to greatly reduce its steam-power output, replacing this by hydro-power and thus effecting economy in overall costs of electric energy. At the same time the company has been able to dispose of an additional block of power. In the new agreement the company has contracted to construct a third transmission line from its plants at Seebe to Calgary. Work on this new line is under way, and it is expected that it will be completed early in the coming fiscal year.

During the year information as to power loads from hydro-plants and the principal steam plants in Alberta was collected for the present and past years. The complete records for 1923 were computed, and this work for past years is being completed as opportunity presents.

Office studies of the power possibilities of the Bow River basin under various storage proposals, and of the resultant flow under these various conditions which had been started in the previous fiscal year were completed. An office study of the power possibilities of the Kananaskis river based on 1913 and 1920 field surveys was made, and the latest flow-data secured. This brings up to date the data available in this office in connection with this stream.

The investigation of absorption losses in lake Newell reservoir was continued in co-operation with the hydrometric engineer of the Canadian Pacific Railway Company's eastern irrigation section and a report on the year's results prepared. The investigation of carriage losses in the main canal of the Canada Land & Irrigation Company was continued and extended to cover the absorption losses in the lake McGregor and Little Bow reservoirs of this system, the officials of this company giving considerable assistance in the construction and maintenance of the necessary stations. Reports on both these questions were prepared showing the results obtained. At the request of the Department of Natural Resources, Canadian Pacific Railway Company, the engineers of this service continued, in co-operation with those of the company, the investigation of the carriage losses of the main canal of the company's western irrigation section. At the request of the Lethbridge Northern irrigation district a brief field investigation of the carriage losses in the upper section of their new main canal was made during May.

In connection with the division of waters of Battle creek under the International Joint Commission, the investigation of carriage losses and diversions on this stream commenced in 1922 was continued and a report prepared.

During the summer of 1923 most of the streams in the southern parts of Alberta and Saskatchewan reached flood stages, and in this connection extensive field investigations as to the causes, extent and resultant damages were carried on. A report covering these floods is in course of preparation and will shortly be submitted.

The annual investigation of snow conditions on the headwaters of the St. Mary river mentioned earlier in this report was carried out in May in co-operation with the United States Geological Survey. A joint report on this investigation was prepared by the district engineer of the Montana Section of the United States Geological Survey and the assistant district chief engineer of this office who had carried out the field investigation.

In addition to requests for published reports containing hydrometric data, a large number of requests for records covering various periods were received from and supplied to other branches and departments of the Dominion Government, the Provincial Governments, municipal authorities, railway corporations, power and irrigation companies, consulting engineers and individuals interested in the development of the water resources or in the run-off conditions. Streamflow records have also been supplied in connection with the construction of a highway bridge over the Athabaska river at Jasper, Alberta, the Souris river in southern Saskatchewan, and in connection with court cases regarding water supply.

District of Manitoba

C. H. Attwood, *District Chief Engineer*

During the fiscal year ending March 31, 1924, the regular stream measurement and power investigatory operations of the Dominion Water Power and Reclamation Service in Manitoba and adjacent districts have been continued.

The scope of the work covered by this district organization comprises the hydrometric work, power survey and storage investigatory work in Manitoba and that portion of the Churchill River lying in northern Saskatchewan, the hydrometric work in that portion of Western Ontario inclusive of, and lying to the west of the Nipigon river.

ORGANIZATION

The local organization of the Dominion Water Power and Reclamation Service headquartered at 231 Chambers of Commerce, Winnipeg, was organized in 1912, and the work then instituted has been carried on and extended from time to time. The duties of the engineers and the hydrometric recorders consist of both field and office work, including surveys, investigations, and the preparation of the data collected in report form, for submission to the head office.

CO-OPERATION

The organization works in co-operation with several departments of the Federal Government and with the Power Commission and the Reclamation Service of Manitoba.

HYDROMETRIC SURVEY

During the past year 102 regular and 28 miscellaneous stations have been maintained on lakes, rivers and tributaries in the following main watersheds: Nelson River, Lake Winnipeg, Winnipeg River, Lake of the Woods, Rainy Lake, English, Red, Assiniboine, Dauphin and Saskatchewan Rivers.

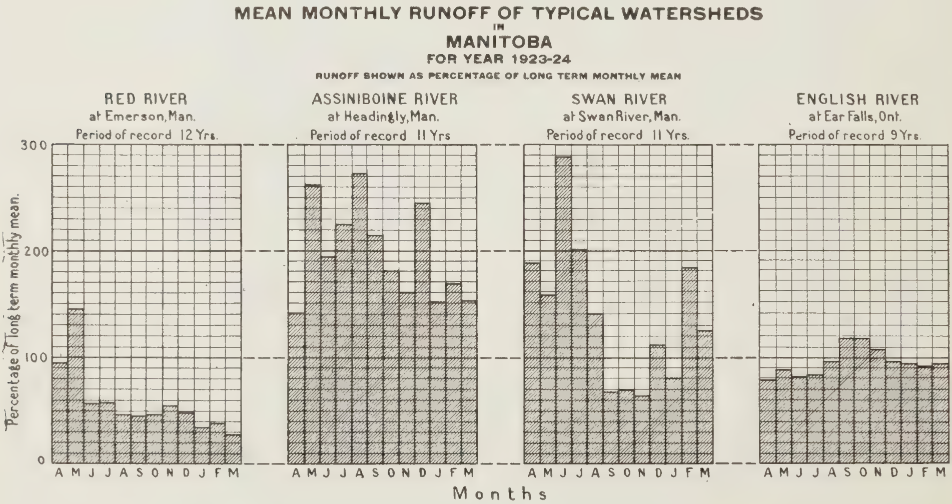
Of the above regular stations there were maintained for power and storage 41 all the year, 6 during open-water and 2 miscellaneous; for drainage and reclamation throughout the year 7 regular and 20 during open-water, together with 16 miscellaneous. Six regular all-year stations were maintained for flood study. On international streams 14 all-year and 6 open-water regular stations were maintained, together with 10 miscellaneous. Three stations were maintained during open-water only for water supply problems, and for statistical purposes 5 all-year stations. Twelve meteorological stations were maintained continuously. In the above classification a number of stations have been maintained for more than one purpose.

Throughout Manitoba, with the exception of the southern portion, both the precipitation and the run-off were above normal. The general flooding throughout the central and southern part of Manitoba during 1923 break-up was the outstanding feature of the year. The snowfall during the winter of 1922-23 was unusually heavy, and most of it remained up to the middle of April, as low temperatures continued up to that date. While the rivers and streams were still covered with a strong ice sheet and the ditches and culverts filled with ice and snow, a sudden rise to high temperatures quickly melted the snowfall and caused a very high run-off which the streams and ditches were for a time unable to carry, resulting in extensive flooding in numerous localities. In addition to the flooding of large areas of land, a number of towns and villages were inundated, some three hundred bridges destroyed or damaged and both highway and railway grades flooded in numerous places. For a time railroad and highway traffic were demoralized throughout the flooded areas, and our information was dependent on the limited observation of our engineers, telephone reports from observers, and the daily press reports.

Apart from the overflowing of the Assiniboine river, which is treated separately under "Special Investigations," the most serious flooding occurred in the Carman district, extending as far west as Glenboro, and easterly to within a few miles of Sanford. In this area a number of towns and villages were, to a greater or less extent, flooded, and numerous washouts of bridges and grades occurred on both the railways and highways. The towns flooded included Carman, Treherne, Brunkild, Roseisle, Sperling and Graysville. At Carman the whole town was under water and the sewerage system was out of order for three or four days.

On the Morris river flood stages were reached and some towns in the vicinity of Morris were isolated. Both the Canadian National Railway and Canadian Pacific Railway bridges just north of the town were partially destroyed by the ice and the rush of water. Along the Seine river from Ste. Anne des Chênes to within a short distance of Winnipeg the land on both sides of the river was flooded for a considerable distance. East of Winnipeg a certain amount of flooding occurred at Dugald on the Canadian National Railway extending northerly to Hazelridge on the Canadian Pacific Railway. Northwest of Selkirk flooding extended over a considerable area, while farther north the Canadian Pacific Railway line running north to Arborg was under water for a number of miles. In Gladstone district a large area of land was flooded, particularly the Big Grass Marsh region lying north of the town. In the vicinity of Gladstone and for some distance towards the southeast the land was practically under water, though at Gladstone itself no serious flooding occurred. For some days the town was isolated owing to washouts on all the railroads entering the town.

Plate 5



Though there was practically no flooding in Winnipeg, in some of its suburbs it was quite extensive. The most serious occurred west of the city, where the villages of Brooklands and Weston were under water for some days. All flooding ceased, however, when the small creeks and ditches were cleared of the ice and snow.

On the Qu'Appelle river at Tantallon higher stages than those of last year occurred. Though a certain amount of flooding occurred in Tantallon, no particular damage was done, nor was the area flooded outside of the town of any considerable extent.

In analyzing the run-off throughout the district for the year ending March 31, 1924, the following streams have been chosen as typical of conditions in their locality (See Plate 5).

Red river—Emerson, Manitoba.
Assiniboine river—Headingley, Manitoba.
Swan river—Swan river, Manitoba.
English river—Ear Falls, Ontario.

In the southwestern and midwestern sections of the province as exemplified by the Assiniboine and Swan rivers, the average run-off was high being respectively 210 and 175 per cent of the mean of the years of record. Flood run-off did not however reach a maximum rate, that of the Assiniboine being 0.35 second-foot per square mile or 96 per cent of the previous maximum and the Swan 5.91 second-feet per square mile or 86 per cent of the previous maximum. Minimum run-off in both watersheds occurred during winter months, and while at a low rate of 0.006 second-foot in the southwestern area, exceeded the previous low record of 0.001 second-foot per square mile.

Precipitation during the year in the above areas ranged from 127 per cent of the long-term mean in the Assiniboine watershed to 87 per cent of the mean in the Swan River watershed.

In the southerly portion of the province as typified by the Red river, low precipitation and run-off were encountered, the former being 91 per cent of the long-term mean and the latter only 80 per cent. Similar to the westerly portion of the province the rate of run-off during flood was not excessive, the maximum rate for the year being 0.751 second-foot per square mile as compared with the extreme recorded maximum of 1.335 second-feet in April 1916. During winter months the rate of run-off dropped to the exceedingly low rate of 0.006 second-foot per square mile closely approximating to the previous recorded minimum of 0.005.

In the Laurentian area in the southeasterly portion of Manitoba and the extreme westerly section of Ontario, run-off, as typified by the English river, was practically normal, being 95 per cent of the long-term mean while precipitation was 98.5 per cent of the mean. Similar to all other sections of the province the rate of flood run-off was not excessive being at a rate of 0.793 second-foot per square mile or 44 per cent of the maximum recorded. Minimum run-off, however, occurring in April was at a rate of 0.273 second-foot, the lowest recorded for the past eight years.

In the territory covered by this report the past winter has been exceptionally mild, with a very light snowfall. With the exception of the month of January the temperatures have been above normal. At the end of March a large amount of the snow had disappeared, and unless there is exceptionally heavy precipitation during April the usual high run-off will not occur.

SPECIAL INVESTIGATIONS

During the year investigations were greatly curtailed, only the most urgent being undertaken. These were as follows:—

Applications were received in December for the rights to develop water-power on the Whiteshell and Roseau rivers, but with the consent of the applicants the investigations of these were held over until spring.

Lake Manitoba.—Following a petition from the Manitoba Government to the Federal Government respecting the lowering of lake Manitoba to prevent flooding of the hay lands adjacent to the lake shore, the district chief engineer, in July last, accompanied by Mr. J. E. St. Laurent, district engineer of the Department of Public Works, and Mr. W. J. Ward, M.P. for Dauphin, carried out a personal inspection of conditions on the northeasterly arm of the lake and its outlet. To assist the investigations, which were made by the Depart-

ment of Public Works, gauging stations were established by this office on lake Manitoba at Steep Rock and on the Waterhen river.

Assiniboine River Flood.—Floods, which were experienced in the spring of 1922 were again suffered on the Assiniboine in 1923. The predisposing cause of the 1922 flood was the heavy rainfall just prior to freeze-up which left the ground saturated and the lakes and swamps at high levels; heavy precipitation upon the not excessive winter snowfall followed by high temperature brought about the flood.

In 1923, flood, on the contrary, was almost entirely due to the sudden change to high temperatures which commenced about the middle of April following a severe winter during which much snow accumulated. The 1923 flood occurred in two stages, the first beginning about April 18 was due to the sudden appearance of vast quantities of water released from melting snow, which, unable to penetrate the frozen soil, discharged rapidly into the various tributaries of the Assiniboine. Conditions were made worse by jams of ice in creek, culvert, and river, because the flood run-off occurred before the ice melted and the natural drainage channels were called upon to function under adverse conditions.

The second stage of the flood was a consequence of the first. Although jams were dynamited and culverts cleared as quickly as possible, the passage of water had been delayed to such an extent that the run-off from the upper portion of the basin, arriving about the end of April, found the river and its main tributaries still very swollen, and augmented the flood to such an extent that at Brandon and Portage la Prairie stages even higher than those of the 1922 flood were experienced. The peak of this flood was not of long duration, but its recession though continuous was slow, and flooding of the valley of the Assiniboine did not finally cease until near the end of May.

The floods of 1923 submerged many miles of railway and highway whilst a large number of bridges and culverts were damaged or destroyed; in addition a number of sewage systems were temporarily put out of order. The damage to agriculture did not prove as severe as was first feared, for the flood occurred before seeding had taken place, and after its recession it was found possible to seed a large portion of the land that had been submerged.

Lake of the Woods.—In connection with the provision of increased outflow capacity from the lake of the Woods, additional soundings of Portage bay were secured at the request of the Lake of the Woods Control Board in October.

Upper Rainy Boundary Waters.—Arising from proposals submitted to the Dominion Government for the development of storage reservoirs in the boundary waters above Rainy lake, arrangements were made by the Lake of the Woods Control Board for a reconnaissance survey of these boundary waters by this office. A field party carried on the survey during August, September, and October. A reconnaissance power survey was made on the Namakan river between lac La Croix and Namakan lake, and a reconnaissance of the boundary waters between these lakes to determine the feasibility of diversion and power along the boundary. At the falls and rapids which occur along this part of the boundary detailed surveys were made. Reconnaissances to determine the feasible range of storage were made on the following lakes.—La Croix, Iron, Crooked, Basswood, Birch, Knife, and Saganaga, together with a survey of the outlet of Northern Light lake, which lies wholly in Canada. At controlling points along the waterway discharge measurements were secured as the survey proceeded.

The results of this survey show that while storage on these lakes is feasible, the regulation that may be secured can only be determined after a thorough study of run-off conditions and the submission of authoritative evidence from existing interests.

In addition to the summer survey, an officer of this organization made a trip late in the winter to secure measurements of flow at the outlets of the major lakes.

The hydrometric records of the service have been freely drawn on by federal, provincial and municipal bodies and by the railways, corporations, and engineers in connection with the design and construction of bridges, trestles, culverts, drainage, and power projects and for legal evidence.

CONSTRUCTION

Work was continued during the year on the construction of the Great Falls development of the Manitoba Power Company, but with a greatly reduced force. In connection with the rapid progress of the construction of the power-house and the installation of the two units of the initial development in the preceding year, a great deal of temporary work was proceeded with in order to put the plant into operation. Consequently during the year now under review, there remained considerable work to be completed in connection with the power-house. The outside walls and partitions in the power-house were completed, the roof finished, and the floors were brought to grade and surfaced. Stairways were placed, and the power-house building is now practically completed. All temporary wiring, all temporary installation of switchboards, control boards, transformers and machinery and transmission poles for the outgoing line, were removed and the permanent apparatus installed and connected up. During the summer months the concrete portions of the dam were completed, the stoney sluice gates were erected and put into operation. Excavation of the Whitemud Falls channel proceeded throughout the summer, the work being successfully completed with the blowing up of the holding cofferdams in October, and the lowering of the river level nine and one-half feet in the tailrace. The earth embankment section of the dam was completed late in the fall and work was continued on the construction of the rock-fill section. The rock-fill was brought practically up to grade, and the clay-seal placed, and late in November the forebay level was raised to elevation 801, giving an operating head of 48 feet. Some leakage occurs through the rock-fill and some additional work is required to complete this section of the dam. The forebay was cleared up to the 805 contour during the autumn months. The Fraser, Brace Construction Company contract was completed at the end of October, since which date operations have been carried on by the Manitoba Power Company. Very little construction plant remains on the job. The railway tract, transmission line and telephone line to Whitemud falls were dismantled. A new single circuit, wooden pole transmission line was completed between lac du Bonnet and the terminal station in Winnipeg and power is now being delivered to the Winnipeg Electric Company.

District of Ontario

S. S. Scovil, *District Chief Engineer*

During the fiscal year ending March 31, 1924, the regular stream measurement and power investigatory operations of the Dominion Water Power and Reclamation Service in the province of Ontario have been continued, consistent with the terms of the co-operative agreement of October 1, 1919, between the Department of the Interior and the Hydro-Electric Power Commission of Ontario.

ORGANIZATION

The work in Ontario has been continued under the direction of the district chief engineer's office at the corner of Metcalfe and Slater streets, Ottawa, with one sub-office at McCool Block, North Bay, as a centre for field opera-

tions. The hydrometric investigations in the province west of and including the Nipigon river were, as in the previous year, carried on under the direction of the district office at Winnipeg.

CO-OPERATION

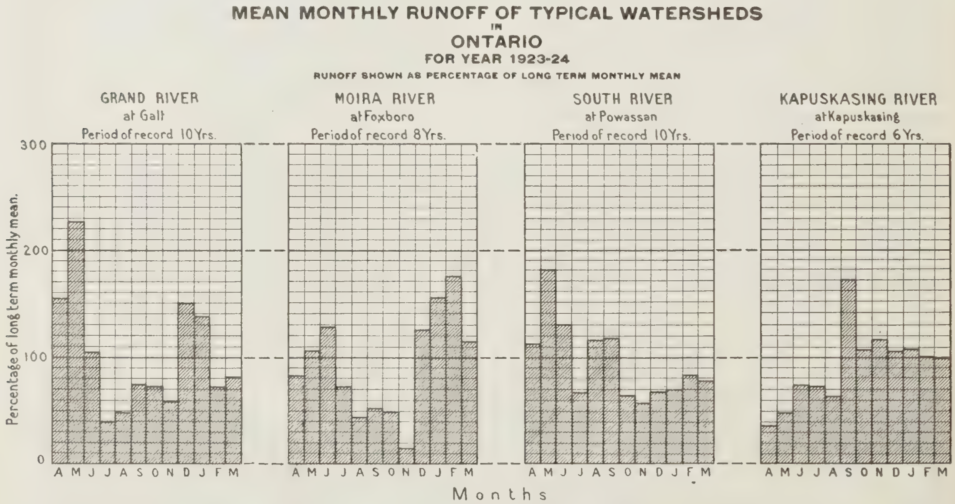
In pursuing the field and office investigations, the closest co-operation has been maintained with the officers of the Hydro-Electric Power Commission. Valuable assistance has been given the engineers of the district by various persons and corporations interested in the securing of hydrological data. In particular, reference should be made to the co-operation carried on with the following companies:—the Abitibi Power and Paper Company, the Algoma Power Company, the Algoma Steel Corporation, the International Nickel Company of Canada, Limited, the Kaministiquia Power Company, the Mattagami Pulp and Paper Company, the Mississippi River Improvement Company, the Pigeon River Lumber Company, the Spanish River Pulp and Paper Company, the Spruce Falls Company, the Northern Ontario Power Company, Messrs. Sutcliffe & Neelands, and Messrs. Kerry & Chace.

HYDROMETRIC SURVEY

During the climatic year ending September 30, 1923, fifty-nine regular stations were maintained on rivers and tributaries in the following main watersheds; Hudson bay, lake Superior, lake Huron, lake St. Clair, lake Erie, lake Ontario and Ottawa river.

Of the above stations forty-five were maintained for power purposes. Eleven stations were maintained for flood and drainage purposes, two stations for purposes of domestic water supply, and one, on an international river, for the determination of international power and control problems. Since September 30, six stations that were maintained for flood purposes, and one for power purposes, have been discontinued.

PLATE 6



With the exception of the northern portion of the province the run-off for the year was above normal. This is illustrated by the accompanying graph (Plate 6) showing the monthly run-off as a percentage of the average flow over a number of years.

In the southwestern district the records of the Grand river at Galt covering a period of ten years show an average run-off for the year of 0.904 second-foot

per square mile or 115 per cent of the mean for the period of record. The flood inflow during April, May and June, as well as the flow during December and January, was above normal. During these five months the run-off ranged from 3.39 second-feet per square mile in April or 154 per cent of the mean for the period of record to 0.471 second-foot per square mile in June, or 104 per cent of the ten year average. The mean for May reached a new high level of 1.868 second-feet per square mile or 227 per cent of the mean for the previous years. The remaining months were below normal, the minimum flow occurring during August with an average run-off of 1.00 second-foot per square mile.

In the eastern district the mean run-off conditions during the year were above normal, as is shown by the records of the Moira river at Foxboro. The average flow for the year was 0.982 second-foot per square mile or 102 per cent of the mean for the period of record. The flood-inflow during April and May, as well as the flow during the winter months December, January, February and March, was above normal. During these months the flow varied from 3.304 second-feet per square mile in April to 0.775 second-foot per square mile in December. The remaining portion of the year was below normal, the minimum flow occurring during September when the run-off was 0.044 second-foot per square mile.

In the North Bay district the mean run-off for the year was above normal, as shown by records of the South river at Powassan covering a period of ten years. The average flow for the year was 1.500 second-feet per square mile or 102 per cent of the mean run-off of 1.472 second-feet per square mile over the period of record. The flood inflow during April, May and June, as well as the flow during August and September, was above normal. During these months the flow ranged from 5.408 second-feet per square mile in April to 0.663 second-foot per square mile in August. The remaining months were below normal, the minimum flow occurring in February with a mean flow of 0.43 second-foot per square mile.

In the northern district the mean run-off for the year was subnormal, as shown by the records of the Kapuskasing river covering a period of seven years. The average flow for the year was 0.595 second-foot per square mile or 74 per cent of the mean run-off of 0.800 second-foot per square mile over the period of record. The average flows for the seven months September to March were above normal, and ranged from 0.897 second-foot per square mile in September to 0.21 second-foot in February. The flow during the remaining months of the year was below normal and varied from 1.589 second-feet in May to 0.191 second-foot in August.

SPECIAL INVESTIGATIONS

During the year considerable progress was made in securing data in connection with developed and undeveloped water-powers and storage resources of the province. A synopsis of the power resources of the following rivers was completed, Black, Blanche, Magpie, Michipicoten, Mattawa, Montreal, Mississagi, Gravel, Pic, Steel and Whitefish, Kaministikwia, White, Bremner, Pucaswa, Dog and Dore.

Niagara River Investigation.—Investigation of the flow and hydraulic characteristics continued throughout the year. With the continued drop in level of lake Erie, discharge measurements were secured at a very low stage and it has been possible to develop a discharge equation based on a range of two and a half feet in lake level. In addition to this work, studies of the relationship between governing pool levels in the Niagara river were continued. The staff have also assisted in the discharge rating of the various power-houses at Niagara Falls.

District of Quebec

L. G. Denis, *District Chief Engineer*

Basic hydrometric and allied investigatory work was continued by the Dominion Water Power and Reclamation Service in the province of Quebec in co-operation with the Quebec Streams Commission as provided for in the agreement between the latter organization and the Department of the Interior. This agreement has been in operation since October 1, 1922, when the various hydrometric stations in the province were taken over and operated in co-operation.

ORGANIZATION

The work in Quebec is carried out under the direction of the district chief engineer's office at 201 Inspector street, Montreal, close relation being maintained with the Quebec Streams Commission whose head office is located in the same city.

CO-OPERATION

In addition to the definite co-operation with the Quebec Streams Commission for the work in Quebec province other very beneficial co-operative activities are made possible with private corporations, including the Shawinigan Water & Power Company, Quebec Development Company, Laurentian Power Company, Price Bros., Portneuf Hydraulic Company, and Lower St. Lawrence Power Company.

HYDROMETRIC SURVEY

During the past year there were 36 regular hydrometric stations maintained under co-operative agreement with the Quebec Streams Commission in the following districts of the province; Eastern Townships, North of St. Lawrence between Quebec and Montreal, Lower Ottawa basin, Lower St. Lawrence, and Saguenay basin. One of these stations is not visited in winter, 3 others are at outlets of storage reservoirs, 4 are operated mainly for flood observations and 8 are in co-operation with private organizations. In addition there are 12 stations where gauge heights only are recorded.

Run-off conditions observed on the various streams of the province during the past year were generally more favourable than normally. While the total for the year may have been slightly below normal, the flow was better distributed throughout the year, being well above normal during periods when it was most needed. The severe winter of 1922-23 was not followed by extreme floods, while heavy rains which occurred in the autumn of 1923 materially helped to increase the run-off during the comparatively moderate winter just past. These conditions are illustrated on Plate 7 showing the monthly run-off as a percentage of the average flow over a number of years at four typical stations selected in different portions of the province.

These typical stations (See Plate 7) are located at Grand'mère on the St. Maurice river, at Richmond on the St. François river, at St. Rose Dégelé on the Madawaska river, and at Amos on the Harricanaw river. On either side of the middle St. Lawrence lie the St. Maurice and St. François rivers which are regulated by the Gouin and Allard dams respectively, with other storages in their respective watersheds; the average run-off of both rivers has been very near normal, or 89 per cent for the St. Maurice and 112 per cent for the St. François. In both cases the flow was maintained well above normal during the critical periods. At flood the respective run-offs per square mile were 7.16 and 14.9 second-feet or 70 per cent and 85 per cent of previous maximums and during the low winter period 0.77 and 0.58 second-foot or 375 per cent and 264 per cent of corresponding previous minimum in each case.

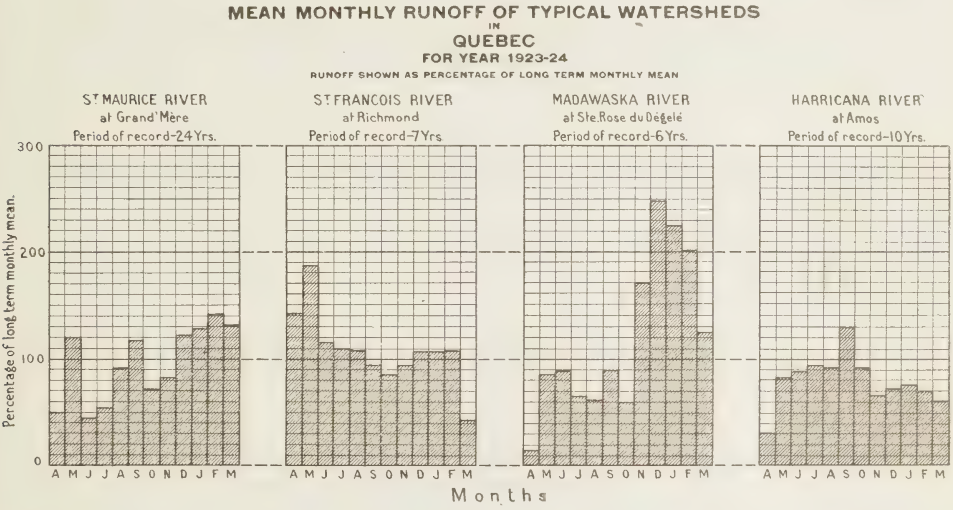
On the Madawaska river the average run-off has also been practically normal, namely 95 per cent. The run-off per square mile at flood was 6.74 second-feet or 63 per cent of the previous maximum, and during the low winter period was estimated at 0.052 second-foot, or the same as corresponding previous minimum.

In the more northerly portion of the province, the Harricanaw river had an average run-off slightly below normal, or 80 per cent. The run-off per square mile at flood was 3.7 second-feet, or 56 per cent of the previous maximum, and during the low winter period, 0.27 second-foot, or 136 per cent of the corresponding previous minimum.

SPECIAL INVESTIGATIONS

Work was continued on securing, classifying and summarizing in proper form all published and otherwise available data on both developed and undeveloped water-powers on the rivers of Quebec province. This information

PLATE 7



covers practically all the known rivers of the province, and is very useful in satisfying various requests for information in this connection. Summaries and tabular statements for the Water Resources Inventory have also been prepared and brought to date from these data, and thus far regular synopses have been completed and revised covering the following rivers: the Ottawa and its tributaries entering from the north; the tributaries of the St. Lawrence entering it from the north between Montreal and Godbout river, including the Lake St. John or Saguenay River basin; southern tributaries of the St. Lawrence above Montreal and the St. Francois river; also the Manitou and St. John rivers on the north shore of the lower St. Lawrence.

An investigation has been initiated on Des Prairies river in regard to general winter discharges and levels in connection with proposed power development on this river.

District of the Maritime Provinces

K. H. Smith, *District Chief Engineer*

During the fiscal year ending March 31, 1924, the regular stream measurement and power investigatory operations of the Dominion Water Power and

Reclamation Service in the Maritime Provinces were continued consistent with the terms of the co-operative agreement of July 1, 1919, between the Department of the Interior and the governments of Nova Scotia, New Brunswick, and Prince Edward Island.

ORGANIZATION

There are two main divisions of the work; first, the acquirement of runoff data so that the water supply in connection with water-power projects, domestic supply or manufacturing processes can be authoritatively estimated, and second, the actual surveys and field and office investigations of power rivers and sites so that ultimately all such fixed data in reference to the power resources of the district will be matters of exact knowledge. The first of these divisions represents a continuous process of recording scientific data, the second represents a more or less fixed quantity of work which, although the total is large, is steadily year by year approaching completion.

Besides the two main divisions, the staff of the Dominion Water Power and Reclamation Service in this district acts in an advisory and consultant capacity to the Provincial Governments and to municipalities, corporations, and individuals on specific problems and projects where their work and possession of data peculiarly fit them. The headquarters of the district are located at 193 Hollis street, Halifax, Nova Scotia.

CO-OPERATION

Under the agreements alluded to above, the work is necessarily co-operative in a large measure as far as the Provincial Governments are concerned. The sequence of the investigations undertaken is made to conform with their wishes. In some cases field parties, furnished by the commissions, work under the direction of Dominion Water Power and Reclamation Service officials where very detailed work is required.

In many cases investigations have been made at the request of municipalities and the practical and economic feasibility of proposed development analysed and reported upon.

HYDROMETRIC SURVEY

During the year thirty-four gauging stations were maintained—21 in Nova Scotia, 10 in New Brunswick, and 3 in Prince Edward Island. Twelve of the rivers gauged in Nova Scotia are important power streams, and the remaining nine are representative streams on which records are desired for statistical purposes to serve as the basis for estimates on other streams in the district. The ten rivers in New Brunswick are, with the exception of the Kennebacasis, potential sources of power, and in addition are so distributed as to give added value to the records for comparative estimates of flow and power on other streams. In Prince Edward Island there are no large power sites, and the three gauging stations maintained are valuable only for statistical purposes in estimates of water supply for the numerous small sites which do occur.

All stream-flow records for the year ending September 30, 1923, have been computed for publication. Previous records have appeared in Water Resources Papers 29 and 37, and in the Nova Scotia Water Power Commission's Reports for 1916, 1917, and 1918.

A severe flood occurred in New Brunswick on May 1, which resulted in heavy damage particularly in the southern part of the province. During the summer and fall the New Brunswick streams were unusually low, and in the southern portion of the province, in the same district which experienced the destructive spring floods, the summer drought was of unusual severity.

Four stations have been selected to typify the run-off conditions in different portions of the Maritime Provinces. These are,—the St. Mary river, as repre-

sentative of the eastern portion of Nova Scotia; the Medway for western Nova Scotia; the Lepreau for southern New Brunswick; and the Miramichi for the central and northern portions of the last province.

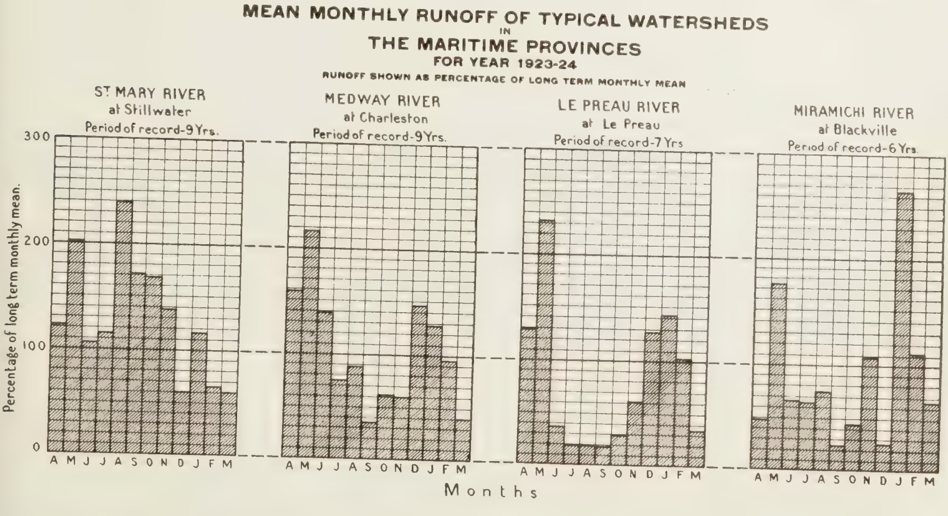
In the eastern half of Nova Scotia, of which the St. Mary river is characteristic, the run-off for the year ending March 31 was 3.2 second-feet per square mile, equal to about 123 per cent of the average. The highest flood during the year of 23 second-feet per square mile occurred in May and was 67 per cent of the maximum on record; the minimum flow which occurred in September was 0.35 second-foot per square mile against a minimum of 0.04 in 1921. A flood of 10,200 second-feet occurred in August which, although slightly less than the spring flood, is unusual for the season in which it occurred.

The streams in the western portion of Nova Scotia as typified by the Medway never had an annual run-off of 3.3 second-feet per square mile, or 121 per cent of the average. The maximum flood during the year was 12.4 second-feet per square mile, whereas the maximum was 14.1 second-feet per square mile in 1920. The minimum flow for the year was 0.21 second-foot per square mile in September. A minimum of 0.07 occurred in 1921.

In the southern district of New Brunswick as exemplified by the records of the Lepreau river, the run-off for the year was 103 per cent of the long term mean. An extraordinary flood, however, occurred on April 30 when run-offs approximating 150 second-feet per square mile were recorded. The summer and fall was a season of long and severe drought. The minimum flow occurred in August and was equivalent to 0.04 second-foot per square mile. During the six months from June to November the mean flow was only about 30 per cent of the long term average for that six months period.

On the Miramichi river, and in the territory for which it is representative, the mean run-off for the year was equal to the long-term mean. The great flood of May 1 was equivalent to 52 second-feet per square mile and was greatly in excess of any previously known flood. The lowest flow recorded during the period of records occurred in September and was equal to 0.17 second-foot per square mile.

Plate 8



The attached graph (Plate 8) giving the mean monthly run-off on four typical streams expressed as a percentage of the long term mean shows the varying conditions which are met with in different portions of this district.

SPECIAL INVESTIGATIONS

At Grand falls, in New Brunswick, a triangulation and plane-table survey was carried for twenty miles above the falls to determine the flowage and pondage that will result from the proposed power dam. This work was carried out in co-operation with the New Brunswick Electric Power Commission, who supplied some assistance to the Dominion Water Power and Reclamation Service officials making the survey.

Quite extensive investigations were made in New Brunswick following the extraordinary flood of May 1. In this connection special studies of the St. Croix river were undertaken at the request of the Canadian Cotton Co. Limited, and a scheme recommended to prevent a recurrence of such damage as resulted from that flood.

An investigation of the power possibilities of Goldsmith brook near St. Stephen, New Brunswick, was undertaken at the request of Ganong Brothers, Limited.

In Nova Scotia the Wallace river, Salmon river, East river, Chester, and West river, Antigonish, were surveyed and reported upon in compliance with the wishes of the several municipalities interested.

Surveys in great detail, and close estimates of power and cost were completed for the St. Croix river in Nova Scotia, as this river has been under consideration by the Nova Scotia Power Commission as a probable source of supply for the towns of Truro, Springhill, and Amherst.

Considerable attention and study was given to problems arising from other projects of the provincial commissions, notably in the case of the Malay Falls and Tidewater developments of East River Sheet Harbour.

A great many requests for information were received from various sources. In some cases such enquiries could be met by reference to office data files, and in others special field work was required, but an endeavour is made to meet as promptly as possible all reasonable requests for information and assistance.

There are now operating in Nova Scotia and New Brunswick four government-owned plants of a total capacity of 28,000 horse-power at a total investment of about $5,000,000. In addition to these there are a number of privately-owned water-power developments supplying energy to various communities and to pulp and paper mills. A considerable proportion of these enterprises were undertaken as a result of the information secured under the co-operative agreement already referred to whilst all benefit from the data secured by the Dominion Water-Power and Reclamation Service.

As examples of direct negative benefits arising from the possession of accurate stream-flow data during the past fiscal year may be mentioned the abandonment of such projects as the Salmon river and Wallace river because stream-flow records showed insufficient flow.

The utilization of computations and records in the case of the flood prevention work on the St. Croix river is cited as an instance of indirect benefits and the large number of requests for run-off data and other information is evidence of the many uses to which the records are put.

PART III

RECLAMATION

PART III

RECLAMATION

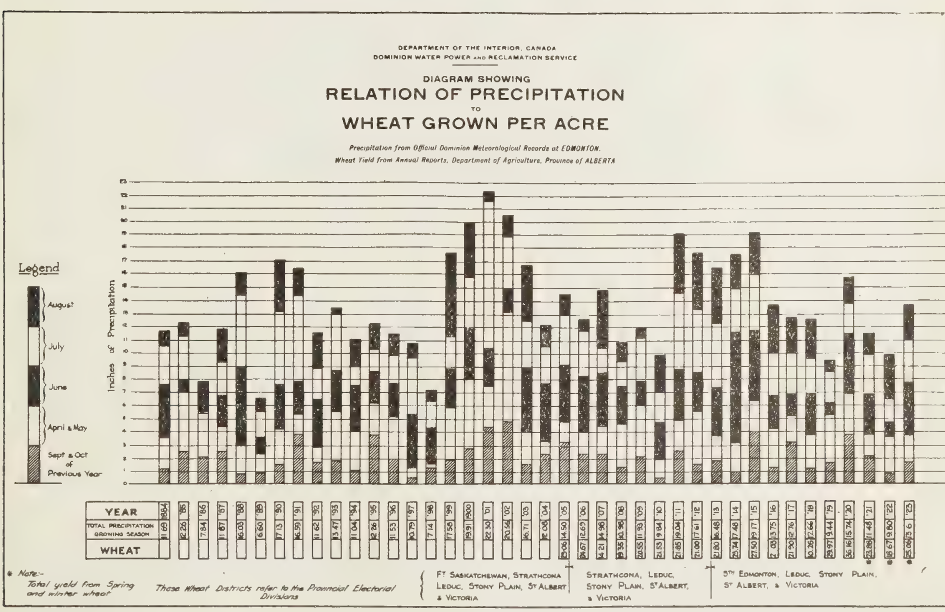
Irrigation Surveys and Inspections

With a view to economy the report on the work carried on during the past year has been condensed as much as possible, and only such matter submitted as is necessary for record purposes. All original reports are filed both at Calgary and Ottawa and more detailed information is available to those interested in any particular feature of the work.

GENERAL

The graphs illustrating the relation of precipitation during the growing season to wheat grown per acre have again been prepared for the following districts: Edmonton, Calgary, Lethbridge and Medicine Hat. A 39-year record is now available, from which a study can be made of the amount of rain which was received each month during the growing season. It also includes the precipitation received during September and October of the previous year because it is considered that most of this moisture is stored in the ground for the following year's crop. These graphs, when taken by districts and carefully

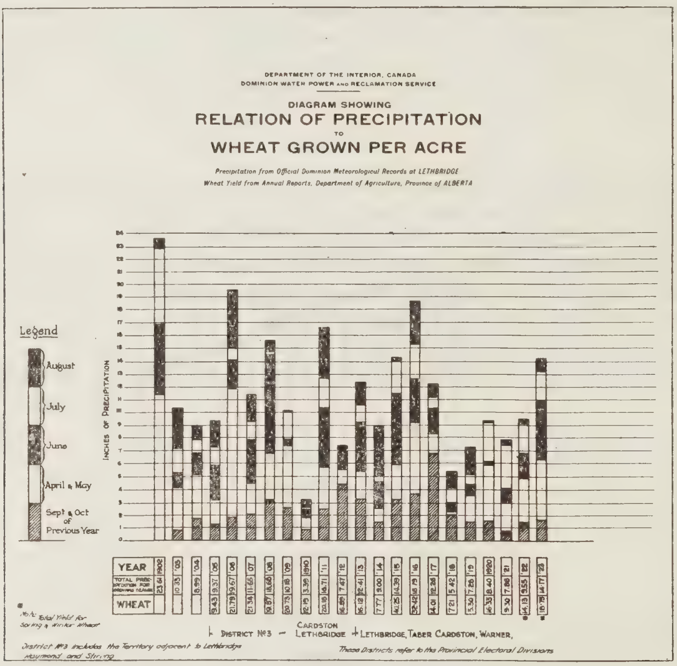
Plate 9



studied, clearly indicate that the agriculturist in any of the districts covered must expect periodic dry years. The information also suggests that the success or failure of the farming industry should be considered over a period of years rather than from year to year. By considering long term averages both as regards crop yields and value of returns—the farmers individually should be prepared to meet the short drought periods and the business and financial insti-

tutions should realize that such conditions are only periodic. With a broad and intelligent understanding on the part of the financial and business interests, of the agricultural cycles peculiar to the western provinces, it is considered that the periods of panic which so often follow a year or two of drought might in the future give place to more helpful methods of finance. A perusal of the precipitation chart, particularly that for the Calgary district, shows that the rainfall

Plate 10



received during the growing season of 1923 was over twice that received during the same period in the previous six years. This generous precipitation greatly increased the volume of crops, and has created a more optimistic spirit and outlook for the future amongst the farming communities. The Edmonton, Lethbridge, and Medicine Hat graphs also show a substantial increase in the amount of precipitation received.

ORGANIZATION

At the completion of the fiscal year, March 31, 1923, a considerable reduction in the staff was made; the personnel principally affected being the temporary field staff, whose services were no longer required in view of the completion of the major portion of the large surveys and field investigations in connection with the larger proposed irrigation projects. During the past fiscal year, a total of 71 persons was employed in the following divisions: Office staff, 26; Field staff, 16; seasonal temporary field employees, 29.

WATER ADMINISTRATION

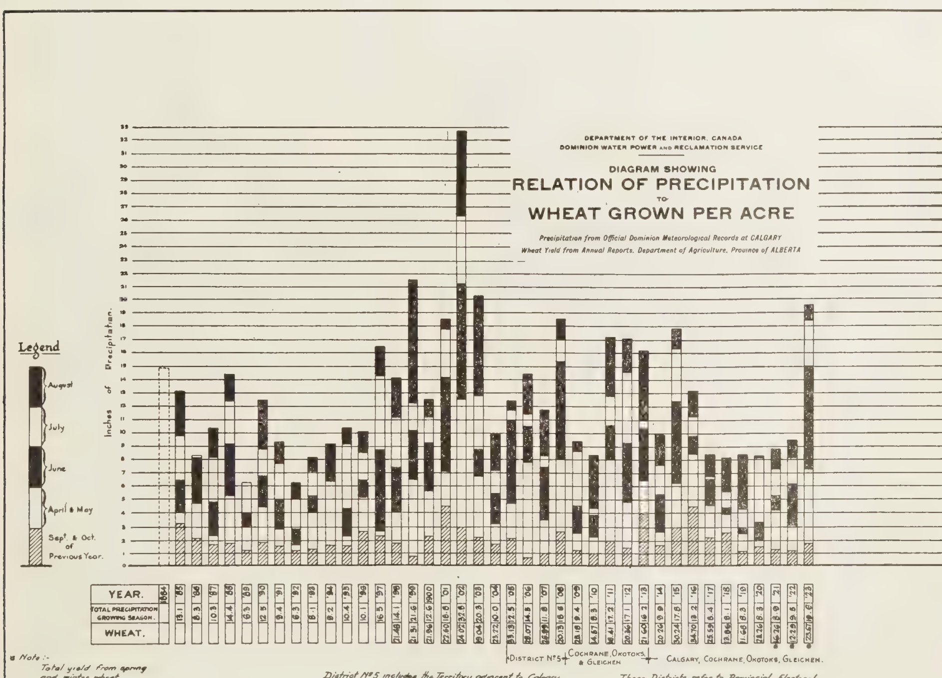
The amount of current administration work carried out during the year 1923 is roughly indicated by the following figures:—

—	Dec., 1922	Dec., 1923	Increase	Decrease
Licenses in good standing	830	872	42	....
Permits	29	37	8	....
Authorizations	323	355	32	....
Schemes under investigation	357	262	....	95
Cancellations	897	1,006	109	....
Total	2,436			
New applications received during 1923	96			
Totals	2,532	2,532	191	95

The official operations during the year were as follows:—

Applications filed	96
Authorizations issued	103
Licenses issued	54
Permits issued	12
Cancellations	109
Total	374

PLATE 11

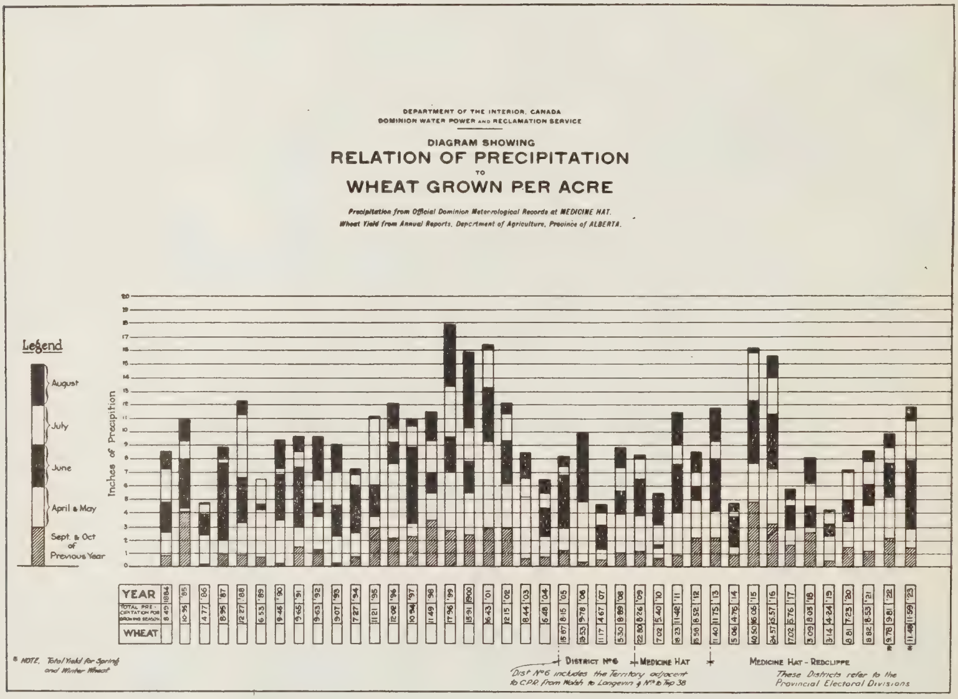


Owing to the increased precipitation in the growing season of 1923 the number of applications has fallen considerably as compared with recent years, but is still above the average up to 1918. Attention is directed to the fact that the total number of schemes in good standing is now 1,526 as compared with about 1,100 at the end of 1918, and the number of authorized schemes awaiting final inspection for license is greater than at any previous time. Licenses may be cancelled when any licensee abandons or ceases to use or

wastes any water to which his license entitles him, and this is an important provision for the protection of other licensees who make satisfactory use of their schemes.

Water Administration Maps.—One hundred completed tracings are now available for reference purposes, and fourteen draft maps are in course of preparation. These maps are essential for all studies of available water supply and are being brought up-to-date to show the progress of all schemes included in the areas affected, and will eventually replace the smaller scale sectional maps which were formerly in use. Extensive changes in drainage areas are being noted as surveys are extended by our own and other services, and the resultant run-off in acre-feet per square mile is found to be more consistent as additional information becomes available.

PLATE 12



Run-off Studies.—The adoption of a standard period (1911 to 1920) has been very successful in securing consistency in comparative studies of water supply, but investigations show that many of the early stream-records are incomplete so that extensive study has been necessary to secure essential accuracy. Close co-operation with the hydrometric service is important in order that local conditions may be given due consideration, and a system of estimating supplies from areas not covered by hydrometric records, or only partly covered, is being evolved.

The usual methods of correlation are being supplemented by the preparation of maps showing the percentage of normal run-off occurring in each year.

Lake records also afford valuable information as to lake levels which can be used as a check on other run-off data. The effect of lake control under varying conditions is also being studied as circumstances permit.

Flood Discharge.—Investigations are being continued to secure closer estimates of stream flow for the design of spillways and other structures.

While a 10-year period is found to be reasonably accurate for determining the normal supply from most streams, the hydrometric records of exceptional floods in 1923 indicate that a longer term is necessary in connection with the expected flood discharge, and a period of not less than thirty years should be used as a basis for the design of large and expensive structures. Until such records are obtained it will be necessary to assume certain relations between the maxima for say fifteen years and thirty years.

For general purposes the calculations are based on the maximum daily flow, and corrections will be applied to determine the actual peak discharge during the day of maximum discharge for use when the character of a design requires these figures.

Within certain limitations the theory of probability can be applied but theoretical formulæ should be used with caution, and a study of actual observations in relation to time and place in necessary as a check on all estimates of probable flood requirements.

The advantages of systematically plotting all results and analyzing the results as a whole are therefore obvious, and the methods now in progress should eventually lead to economy of field operations in addition to more reliable estimates for purposes of design.

INSPECTION WORK

Special Inspections—Domestic, Municipal, Industrial and Irrigation.

This work was carried out by five field engineers under the supervision of an office engineer, the latter official being responsible for the efficient and economical performance of the work. The five inspection districts and the number of inspections carried out in each are tabulated below:—

District	Number of Inspections made during Season
East Cypress Hills	53
West Cypress Hills	83
Cardston	107
Alberta Special Inspections	67
Saskatchewan Special Inspections	38

The volume of new applications fell off considerably last season, chiefly a reaction as a result of a year of abundant rainfall following a number of years of subnormal precipitation. It has been observed that the rate at which new applications are recorded bears a very close relationship to the amount of precipitation, and varies inversely with it, being very quick to react to even the promise of a year of abundant rainfall and responding more slowly to the effects of a period of subnormal precipitation.

In the main it must be admitted that the progress of development on small irrigation schemes throughout the two provinces has been disappointing. There are of course a few notable exceptions where schemes are operating, and have done so for years, with successful results. These are not situated in any particular locality but are met with here and there throughout the semi-arid belt, a fact which helps to confirm the belief that the work is being carried on along the right lines, and that if proper methods are used very definite benefits may be derived from the application of water. It is surprising that the good examples furnished by the successful irrigators have not resulted in a more consistent use of water on other less successful schemes within the sphere of their influence.

Watermasters.—The three inspecting engineers in charge of the southernmost districts, namely the East Cypress Hills, West Cypress Hills and Cardston districts, were again issued with watermaster warrants for their respective districts. These warrants empower them to adopt certain measures in the regulation of diversions of water in order to settle disputes or complaints which may arise from time to time. There are always a certain number of com-

plaints to investigate and last season was no exception. All those received were investigated promptly and amicable settlements made. This arrangement is very satisfactory and will be continued next season.

Domestic Water Supplies.—As usual there were a number of applications for water for domestic purposes dealt with last season. It is almost invariably found upon investigation that the applicant's source of supply is a coulee or other small watercourse discharging a considerable volume of water during the spring run-off and possibly for a day or so after heavy rains, but is dry the greater part of the year. In order to have a steady, dependable supply for ordinary domestic and stock-watering purposes throughout the summer, it is necessary to so construct the works that the amount required to fulfill the applicant's requirements may be stored. Generally speaking, the works are of a very simple and inexpensive nature, consisting in most cases of an earthen embankment across the channel with an excavated spillway around it. Many such schemes undoubtedly exist of which there are no official records. Whenever these schemes are noticed the owners are advised to protect their own interests by the submission of formal applications for the maintenance of their works. The small expenditure involved in thus legalizing their schemes is considered well spent in the protection afforded.

Municipal Water Consumption Data.—The collection of these data has been continued throughout the past year. The department is indebted to the various towns and cities for their excellent co-operation which has made this work possible. The records have been completed in a manner similar to previous years and are submitted in the tables appended.

Cities and Towns in the Province of Alberta—Daily Record of Water Consumption in Imperial Gallons for the year 1923.

Month	Athabaska						Bassano					
	Population 450						Population 1,000					
	Daily Average for the month	Per Head for domestic purposes	Per Head for industrial purposes	Per Head for other purposes	Per Head for all purposes	Unaccounted for	Daily Average for the month	Per Head for domestic purposes	Per Head for industrial purposes	Per Head for other purposes	Per Head for all purposes	Unaccounted for
January....	8,993	....	....	....	20·0	....	121,291	....	....	....	121·3	....
February...	6,339	....	....	....	14·1	....	131,071	....	....	....	131·1	....
March......	6.774	....	....	....	15·1	....	132,258	....	....	....	132·3	....
April......	9,083	....	....	....	20·1	....	131.000	....	....	....	131·0	....
May........	8,468	....	....	....	18·8	....	158,710	....	....	....	158·7	....
June.......	9,167	....	....	....	20·4	....	148,833	....	....	....	148·8	....
July........	9,194	....	....	....	20·4	....	167,742	....	....	....	167·7	....
August......	13,548	....	....	....	30·1	....	173.064	....	....	....	173·1	....
September .	13,167	....	....	....	29·3	....	159,330	....	....	....	159·3	....
October.....	5,968	....	....	....	13·3	....	165,645	....	....	....	165·6	....
November..	9,750	....	....	....	21·7	....	163.500	....	....	....	163·5	....
December..	6,047	....	....	....	13·4	....	155,806	....	....	....	155·8	....
Average for the year..	8,888	....	....	....	19·8	....	150,850	....	....	....	150·8	....

Cities and Towns in the Province of Alberta—Daily Record of Water Consumption in Imperial Gallons for the year 1923.

Month	Edmonton						Lethbridge					
	Population 60,000						Population 11,000					
	Daily Average for the month	Per Head for domestic purposes	Per Head for industrial purposes	Per Head for other purposes	Per Head for all purposes	Unaccounted for	Daily Average for the month	Per Head for domestic purposes	Per Head for industrial purposes	Per Head for other purposes	Per Head for all purposes	Unaccounted for
January.....	6,478,932	64·8	27·0	16·1	108·0	....	1,346,548	93·9	28·6	....	122·4	....
February...	6,260,715	62·6	26·1	15·7	104·3	....	1,443,035	101·7	29·5	....	131·2	....
March......	5,870,900	58·7	24·5	14·7	97·8	....	1,367,935	94·5	29·9	....	124·4	....
April.......	5,683,900	56·8	23·7	14·2	94·7	....	1,520,433	109·2	29·0	....	138·2	....
May........	5,438,970	54·0	22·7	13·9	90·6	....	1,565,677	117·4	25·0	....	142·3	....
June........	5,024,860	50·2	20·9	12·6	83·7	....	1,371,433	91·8	32·9	....	124·7	....
July........	5,044,613	50·4	21·0	12·6	84·1	....	1,543,354	96·2	40·6	3·6	140·3	....
August......	4,945,129	49·5	20·6	12·3	82·4	....	1,553,838	99·5	39·6	2·1	141·3	....
September..	4,893,266	48·8	20·5	12·2	81·6	....	1,557,200	103·4	35·4	2·7	141·6	....
October.....	4,744,387	47·1	19·8	12·2	79·1	....	1,431,741	75·8	54·4	....	130·2	....
November..	5,054,433	50·0	21·6	12·6	84·2	....	1,397,866	86·6	40·5	....	127·1	....
December..	4,994,500	49·9	20·8	12·5	83·2	....	1,333,548	82·5	38·7	....	121·2	....
Average for the year..	5,358,767	53·5	22·4	13·5	89·4	....	1,452,699	96·0	35·4	0·7	132·1	....

Month	Medicine Hat						Redcliff					
	Population 10,000						Population 1,100					
	Daily Average for the month	Per Head for domestic purposes	Per Head for industrial purposes	Per Head for other purposes	Per Head for all purposes	Unaccounted for	Daily Average for the month	Per Head for domestic purposes	Per Head for industrial purposes	Per Head for other purposes	Per Head for all purposes	Unaccounted for
January.....	1,874,516	....	....	....	187·5	....	100,976	83·9	7·9	....	91·8	....
February...	1,916,428	....	....	....	191·6	....	82,500	66·2	8·8	....	75·0	....
March......	1,970,968	....	....	....	197·0	....	*					
April.......	2,041,667	....	....	....	204·2	....	*					
May........	2,501,290	....	....	....	250·1	....	*					
June........	2,211,067	....	....	....	221·1	....	*					
July........	2,399,355	....	....	....	239·9	....	*					
August......	2,578,710	....	....	....	257,8	....	*					
September..	2,428,000	....	....	....	242,8	....	*					
October.....	1,933,226	....	....	....	193·3	....	*					
November..	1,794,434	....	....	....	179·4	....	100,000	82·7	8·2	....	90·9	....
December..	1,937,742	....	....	....	193·8	....	115,281	97·0	7·8	....	104·8	....
Average for the year..	2,134,206	....	....	....	213·4	....	100,117	82·9	8·1	....	91·0	....

Cities and Towns in the Province of Saskatchewan—Daily Record of Water Consumption in Imperial Gallons for the Year 1923.

Month	Estevan						Kindersley					
	Population 2,300						Population 1,000					
	Daily Average for the month	Per Head for domestic purposes	Per Head for industrial purposes	Per Head for other purposes	Per Head for all purposes	Unaccounted for	Daily Average for the month	Per Head for domestic purposes	Per Head for industrial purposes	Per Head for other purposes	Per Head for all purposes	Unaccounted for
January.....	37,194				16·2	....	16,290	16·3	....	....	16·3	....
February...	38,000	7·5	6·2	2·8	16·5	....	11,531	11·5	....	....	11·5	....
March......	40,682				17·7	....	12·988	13·0	....	....	13·0	....
April.......	36,733				16·0	....	12,329	12·3	....	....	12·3	....
May........	44,355	8·7	10·9	0·6	19·3	....	10,210	10·2	....	....	10·2	....
June........	56,167				24·4	....	8,396	8·4	....	....	8·4	....
July........	58,677				25·5	....	10,325	10·3	....	....	10·3	....
August......	58,871	9·3	14·8		25·6	....	17,809	17·7	0·1	....	17·8	....
September..	48,333				21·0	....	9,181	9·2	....	....	9·2	....
October.....	50,258				21·8	....	9,228	9·2	....	....	9·2	....
November..	47,300	8·0	9·8	2·1	20·6	....	10,133	10·1	....	....	10·1	....
December..	43,710				19·0	....	9,606	9·6	....	....	9·6	....
Average for the year..	46,594	8·6	10·8	1·4	20·3	....	11,514	11·5	....	....	11·5	....

* Records March to October destroyed.

Cities and Towns in the Province of Saskatchewan—Daily Record of Water Consumption in Imperial Gallons for the Year 1923.

Month	Moose Jaw Population 2,300						Weyburn Population 3,200					
	Daily Average for the month	Per Head for domestic purposes	Per Head for industrial purposes	Per Head for other purposes	Per Head for all purposes	Unaccounted for	Daily Average for the month	Per Head for domestic purposes	Per Head for industrial purposes	Per Head for other purposes	Per Head for all purposes	Unaccounted for
January	862,000	36·2	7·0	....	43·1	....	200,006	....	....	....	75·0	....
February	865,000	33·3	10·0	....	43·2	....	200,781	....	....	....	62,7	....
March	866,000	34·5	8·8	....	43·3	....	185,196	....	....	....	57·9	....
April	801,000	32·2	7·9	....	40·0	....	188,016	....	....	....	58·8	....
May	830,000	31·4	10·1	....	41·5	....	204,585	....	....	....	63·9	....
June	863,000	33·7	9·5	....	43·2	....	236,270	....	....	....	73·8	....
July	935,000	37·0	9·7	....	46·8	....	232,560	....	....	....	72·7	....
August	966,000	37·4	10·9	....	48·3	....	236,089	....	....	....	73·8	....
September	981,000	40·1	8·9	....	49·0	....	235,471	....	....	....	73·6	....
October	907,000	33·3	12·0	....	45·4	....	232,837	....	....	....	72·8	....
November	901,000	35·4	9·7	....	45·0	....	225,141	....	....	....	70·4	....
December	862,000	34·1	9·0	....	43·1	....	230,721	....	....	....	72·1	....
Average for the year	886,832	34·9	9·4	....	44·3	....	217,569	....	....	....	68·0	....

Month	North Battleford Population 4,100						Prince Albert Population 7,500					
	Daily Average for the month	Per Head for domestic purposes	Per Head for industrial purposes	Per Head for other purposes	Per Head for all purposes	Unaccounted for	Daily Average for the month	Per Head for domestic purposes	Per Head for industrial purposes	Per Head for other purposes	Per Head for all purposes	Unaccounted for
January	97,405	10·6	1·3	4·6	23·7	7·2	580,919	22·7	28·5	1·3	77·4	24·9
February	96,733	10·6	1·0	4·1	23·6	7·9	576,471	24·1	29·6	0·5	76·9	22·7
March	91,010	11·2	1·8	4·3	22·2	4·7	621,758	20·7	24·2	0·5	82·9	37·6
April	116,645	10·3	1·7	7·4	28·5	9·1	565,576	21·0	25·3	0·6	75·4	28·5
May	110,223	10·7	1·3	2·9	27·4	11·2	480,961	24·2	25·5	2·5	64·2	11·9
June	110,223	14·2	0·8	6·6	26·9	5·3	531,220	25·1	24·8	2·6	70·8	18·3
July	91,103	13·4	1·0	1·9	22·2	6·0	521,203	22·5	23·8	2·7	69·5	20·5
August	99,732	12·0	1·1	3·7	24·3	7·5	500,954	21·0	33·2	3·2	66·8	9·4
September	107,477	14·4	1·0	3·3	26·2	7·5	514,650	23·5	28·9	1·3	68·6	14·9
October	104,344	10·0	3·3	2·7	25·4	9·4	473,335	22·2	30·2	0·8	63·1	9·9
November	101,720	7·3	2·2	7·6	24·8	7·7	472,403	25·2	29·1	2·3	63·0	6·4
December	102,732	10·3	1·9	4·3	25·1	8·6	460,122	21·0	22·1	1·3	61·4	17·0
Average for the year	....	....	....	....	....	....	524,587	22·8	27·1	1·6	70·0	18·5

Month	Regina Population 35,000						Saskatoon Population 27,000					
	Daily Average for the month	Per Head for domestic purposes	Per Head for industrial purposes	Per Head for other purposes	Per Head for all purposes	Unaccounted for	Daily Average for the month	Per Head for domestic purposes	Per Head for industrial purposes	Per Head for other purposes	Per Head for all purposes	Unaccounted for *
January	2,682,221	64·4	10·3	1·9	76·6	....	1,879,258	For Quarter			69·6	
February	2,783,721	63·4	14·2	2·0	79·6	....	1,944,642	30·3	19·4	0·8	72·0	20·1
March	2,785,022	63·6	11·3	4·7	79·6	....	1,902,968				70·5	
April	2,701,678	61·0	13·0	3·2	77·2	....	1,951,533				72·3	
May	2,672,000	61·5	13·2	1·6	76·3	....	2,164,932	26·6	18·0	2·4	80·2	29·4
June	2,541,340	54·5	16·4	1·6	72·6	....	2,065,666				76·5	
July	2,420,226	51·8	15·6	1·8	69·2	....	2,061,225				76·3	
August	2,819,021	59·7	19·5	1·4	80·5	....	1,923,935	29·0	19·8	1·4	71·3	21·9
September	2,855,191	61·9	18·3	1·4	81·6	....	1,850,000				68·5	
October	2,909,601	67·8	13·6	1·8	83·1	....	2,268,389				84·0	
November	2,907,204	65·3	16·0	1·7	83·1	....	2,128,500	29·5	26·0	1·2	78·8	21·2
December	2,778,644	65·2	12·8	1·3	79·4	....	1,917,258				71·0	
Average for the year	2,737,472	61·7	14·5	2·0	78·2	....	200,526	28·8	20·8	1·5	74·3	23·1

*Includes Town of Sutherland.

Cities and Towns in the Province of Saskatchewan—Daily Record of Water Consumption in Imperial Gallons for the Year 1923.

Month	Kamsack — Population *375 — Daily Average for the month	Per Head for domestic purposes	Per Head for industrial purposes	Per Head for other purposes	Per Head for all purposes	Unaccounted for
January	275,336	28·2	564·3	123·1	734·2	18·5
February	218,654	28·0	341·6	115·9	583·1	97·5
March	195,806	26·3	344·7	99·1	522·1	52·0
April	190,267	23·4	248·9	87·1	507·4	148·0
May	180,290	29·2	228·6	82·0	480·8	141·0
June	105,377	23·4	194·4	74·0	281·0	−10·8 surplus
July	131,140	25·6	162·0	78·0	349·7	84·2
August	74,329	25·3	115·5	16·8	198·2	40·8
September	159,223	28·4	324·5	10·1	424·6	61·7
October	181,074	33·6	362·1	5·8	482·9	81·4
November	213,553	28·2	287·6	8·0	569·5	245·7
December	230,390	28·4	325·0	7·2	614·4	253·7
Average for the year	179,436	27·3	291·5	58·6	478·5	101·1

*Only 75 houses supplied or approximately 375 people. This is figure used in computations, although total population is about 2,000.

Cities and Towns in the Province of Alberta—Record of Average Daily Water Consumption in Imperial Gallons for Years 1915-23.

Average for the Year	Per Head Domestic	Per Head Industrial	Per Head other Purposes	Per Head all Purposes	Unaccounted for	Per Head Domestic	Per Head Industrial	Per Head other Purposes	Per Head all Purposes	Unaccounted for
	Edmonton					Lethbridge				
1915	46·0	31·0	3·0	80·0		81·4	32·2	1·5	115·1	
1916	52·5	20·7	5·7	78·9		116·0	41·3	0·7	158·0	
1917	56·3	25·0	9·7	91·0		95·0	55·0		150·0	
1918	58·0	26·2	10·1	94·3		102·2	44·7	3·0	149·9	
1919	56·7	24·6	9·7	91·7		78·1	26·9		107·3	
1920	54·7	23·4	16·2	94·3		91·8	35·1	†6·8	129·1	
1921	54·6	23·4	16·8	94·8		94·2	27·8	1·4	123·4	
1922	62·2	24·9	24·1	111·1		110·8	33·5		145·1	
1923	53·5	22·4	13·5	89·4		96·0	35·4	0·7	132·1	
	Bassano					Carmangay				
1915	6·5	60·2		66·7		41·9		2·0	43·9	
1916						32·6			32·6	
1917	17·9	154·3	95·4	267·6		31·3			31·3	
1918				211·0		29·8		1·0	30·8	
1919				194·7		32·5		1·2	33·7	
1920				158·9		26·2		*3·4	30·3	
1921				137·8						
1922				135·7						
1923				150·8						
	Medicine Hat					Redcliff				
1915	181·0	28·0	15·0	224·0		31·1	6·8		37·9	
1916	214·0			214·0		36·8	22·1	1·0	59·9	
1917	257·0			257·0		42·5	30·3		72·8	
1918				264·0		66·4	22·4		88·8	
1919				234·0		79·1	13·7		92·8	
1920				206·8		67·9	16·2		84·2	
1921				175·3		65·7	9·6	0·46	75·76	
1922				187·9		97·9	7·8		105·6	
1923				213·4		82·9	8·1		91·0‡	
	Athabaska									
1915						14·3			14·3	
1916						10·9			10·9	
1917						24·0			24·0	
1918						27·6			27·6	
1919						26·1			26·1	
1920						44·3			44·3	
1921						33·3			33·3	
1922									27·8	
1923									19·8	

† 4 months. * 7 months. ‡Based on 4 months records.

Cities and Towns in the Province of Saskatchewan—Record of Average Daily Water Consumption in Imperial Gallons for Years 1915-23.

Average for the Year	Per Head Domestic	Per Head Industrial	Per Head other Purposes	Per Head all Purposes	Unaccounted for	Per Head Domestic	Per Head Industrial	Per Head other Purposes	Per Head all Purposes	Unaccounted for
	Regina					Saskatoon				
1915..........	55·0	7·5	0·1	62·6	....	21·6	13·9	2·2	45·6	7·9
1916..........	66·1	7·8	....	68·9	....	21·0	15·4	1·9	52·6	14·3
1917..........	59·2	12·6	0·3	72·1	....	24·4	15·6	5·8	66·4	20·6
1918..........	56·9	11·1	0·1	68·1	....	27·1	17·2	2·4	63·1	16·4
1919..........	42·8	8·3	....	51·2	....	28·0	16·3	1·9	64·1	17·9
1920..........	48·9	9·1	*0·9	58·8	....	29·4	14·3	6·1	74·1	24·4
1921..........	49·6	10·12	2·1	62·5	0·74	29·5	20·3	1·0	72·0	21·2
1922..........	59·2	12·6	2·5	74·5	....	31·0	23·6	1·5	78·4	22·4
1923..........	61·7	14·5	2·0	78·2	....	28·8	20·8	1·5	71·0	23·1
	Weyburn					Estevan				
1915..........	17·4	....	0·4	17·8	....	9·5	7·1	1·5	18·1	....
1916..........	16·9	....	0·3	17·2	....	8·2	5·7	1·0	14·9	....
1917..........	30·1	....	....	30·1	....	9·7	5·5	4·3	19·5	....
1918..........	26·4	....	....	26·4	....	9·3	0·7	7·2	17·2	....
1919..........	25·5	....	....	25·5	....	9·6	2·9	....	12·5	....
1920..........	30·2	....	....	30·2	....	9·3	4·4	....	13·7	....
1921..........	27·1	....	....	27·1	....	6·1	4·7	2·0	12·8	....
1922..........	....	....	....	64·4	....	8·5	6·4	2·9	17·9	....
1923..........	....	....	....	68·0	....	8·6	10·8	1·4	20·3	....
	Moose Jaw					North Battleford				
1915..........	24·1	4·6	....	28·7	....	6·6	1·3	2·7	14·8	4·2
1916..........	35·2	12·3	....	47·5	....	9·5	2·0	4·9	22·7	6·3
1917..........	45·8	13·1	....	58·9	....	10·2	2·2	4·0	23·1	6·7
1918..........	31·6	15·4	....	47·0	....	10·0	4·8	3·0	26·3	8·5
1919..........	24·8	15·1	....	39·9	....	11·5	1·6	4·4	29·7	12·2
1920..........	24·5	14·5	....	39·1	....	11·3	5·8	5·9	34·0	10·9
1921..........	30·9	3·9	6·2	41·0	....	9·7	2·8	2·9	26·7	11·3
1922..........	34·8	9·0	....	43·8	....	11·0	2·8	4·3	34·1	15·9
1923..........	34·9	9·4	....	44·3	....	11·3	1·6	4·4	25·0	7·7
	Kamsack					Kindersley				
1915..........	....	....	....	....	....	4·9	8·4	1·6	14·9	....
1916..........	....	....	....	....	....	5·5	26·8	....	32·3	....
1917..........	....	....	....	....	....	5·8	44·4	....	50·2	....
1918..........	31·6	66·3	....	97·9	....	6·0	8·9	....	14·9	....
1919..........	....	....	....	....	....	7·8	....	....	7·8	....
1920..........	....	....	....	....	....	6·9	17·5	....	21·5	....
1921..........	50·4	724·9	....	775·3	....	8·5	11·01	....	19·51	....
1922..........	50·3	690·2	....	740·6	....	10·1	12·3	....	22·4	....
1923..........	27·3	291·5	58·6	478·5	101·1	11·5	....	....	11·5	....
	Prince Albert									
1921..........	....	....	....	....	....	....	....	....	83·0	....
1922..........	....	....	....	....	....	20·4	23·2	1·9	69·6	20·1
1923..........	....	....	....	....	....	22·8	27·1	1·6	70·0	18·5

* 10 months.

East Cypress Hills District.—This district lies in the southwest corner of the province of Saskatchewan and is bounded on the north by township 14 and on the east by range 11, west of the 3rd meridian. The engineer in charge of this district was employed the greater portion of last season in investigating the ultimate irrigation possibilities on a number of the northern tributaries of the Milk river taking rise in Canada, particularly Battle creek. These data were collected in connection with the International Waterways Treaty. A number of right-of-way surveys in Alberta and Saskatchewan were also made by the engineer in charge of this district. He also carried on the experiments, begun in 1922, in the Maple Creek Test Plots.

The period from March 19 to April 14 was spent in the collection of hydrometric data on Sage creek and Cutbank coulee in the southeast corner of the province of Alberta. Later in the season the inspecting engineer made surveys of two reservoir sites in the Sage Creek valley discovered during his reconnaissance along that stream the previous year.

The actual field inspection season opened on the 25th of April and terminated on the 26th of October. During that period in addition to the

large amount of special investigational work accomplished, fifty-three inspections and fifteen surveys were made, also three gauging stations were established and thirty-nine gaugings made during the season.

The following extracts from the inspector's annual report are of interest: "In this the twelfth annual report by the writer for the same district, it is difficult to mention anything of special interest that has not been fully discussed in previous reports. Practically all of the schemes have been completed and licensed, and have already been operated for several years with varying degrees of success. Although the general average development of the schemes is low and the interest in irrigation shown by the irrigators is disappointingly small, there is to be seen here and there some genuine improvement in irrigation methods.

An encouraging feature of agriculture for this semi-arid district is the increase in the growing of fodder corn as a summer-fallow substitute. It is now grown so extensively around Maple Creek that a very successful corn show was held there this last fall. One farmer near Piapot matured nearly all his corn, and sold it for seed at $2 per bushel. As yet corn raising is in its infancy, but it represents one step in the path back to normalcy and to a more solid basis of agriculture."

West Cypress Hills District.—This district lies in the southeast corner of the province of Alberta, bounded on the north by township 14 and on the west by range 17, west of the 4th meridian.

Althought the work was lighter than in previous years, this district still proved the heaviest of all. Present indications make it reasonable to predict that the number of new applications will be light this coming season, which will make it possible to give more attention to the older schemes.

The engineer in charge was engaged on the collection of early spring run-off data in the vicinity of Medicine Hat from the 16th of March to the 30th of May. During this period he made careful measurements of the water applied on a portion of a typical irrigation scheme in this vicinity. The information gathered will prove of material value in the administration of water, and it is the intention to carry out similar experiments from time to time as opportunity permits on other typical schemes operating under different conditions of soil and water supply.

The regular routine inspection work was commenced on the 31st of May and discontinued on the 28th of November, during which time eigthy-three inspections and twenty-nine surveys were made.

The inspecting engineer in his annual report summarizes the climatic and crop conditions met with last season in this district in a few brief paragraphs, as follows: "The autumn of 1922 was very dry, insufficient precipitation having fallen to sprout fall sown grain. Little snow fell during the winter months, and the spring continued very dry until the last day of May. For the two months following, rain fell liberally over the district. As a result of these climatic conditions fall grains and early sown spring grains were a total loss while late sown grains yielded fair returns. The damage done by cutworms and grasshoppers was very small as compared to that done during the preceding year. Small areas suffered from damage by hail and no rust was reported in the district. As in other years the farther up the slopes of the Cypress hills, the better were the yields of the various crops. On both dry and irrigated farms more time is being devoted to mixed farming than in previous years. It is very noticeable that the older irrigation schemes have netted their owners very profitable returns even during the six dry years preceding 1923, when dry-land farming proved a financial failure to the majority of those engaged in it. On spring-flooded land wheat produced an average of 24 bushels per acre as compared to an 8-bushel yield on adjoining dry land. Other crops yielded corresponding returns."

Cardston District.—This district lies in the southwest corner of the province of Alberta, bounded on the north by township 14 and on the east by range 16, west of the 4th meridian. Irrigation in this district is used mainly as an aid to the growing of fodder crops; the bulk of the schemes being located in the foothill country along the western side where stock-raising is essentially the principal industry of the people on the land. The volume of new work was light in this as in all the other districts last season, giving the engineer in charge an opportunity to visit a considerable number of the older schemes. The field work was commenced on the 2nd of May and discontinued on the 19th of November. During this period 117 inspections and 16 surveys were made.

The following extracts from the inspecting engineer's annual report give an idea of conditions within the district at the present time: " From May 25 until August 9 rainfall was general throughout the district and in the foothills it was heavy. Many of the ranchers considered that the precipitation was sufficient and therefore did not irrigate during the season. On some schemes where irrigation was carried out early in May, yields on the higher levels of hay land were greatly increased. Many irrigators now realize the benefit to be derived from early irrigation, but often owing to the pressure of other work and want of help, they allow opportunities to pass. In this district there are a large number of schemes authorized for construction. On many, good progress has been made with construction work, but on others the progress has been poor owing to owners not being in a position to employ extra labour. There is now a much more hopeful feeling in the district, and many are looking forward to being in a better position financially and hope soon to be able to engage some labour to assist in completing new schemes and some to improve existing schemes. The fine crops after a number of poor ones have given both farmers and ranchers a much brighter outlook."

Alberta Special Inspections District.—Last season this district comprised all of the province of Alberta north of township 13, and west of range 7, west of the 4th meridian. As a matter of economy and to avoid duplication of work all inspections in the vicinity and north of Edmonton were made by the drainage inspector. Last season he made seventeen irrigation inspections involving eight surveys in addition to his regular work. The inspecting engineer in charge of this district started field work on the 23rd of April and finished on the 26th of October, during which time fifty inspections and eleven surveys were made.

The following extracts from the inspector's annual report summarize the conditions met with in his district: " The season of 1923 differed from the preceding ones in the amount of rainfall, which was sufficient to produce bumper crops throughout the district generally, the only exception being the southern part of the Berry Creek district. As a result of these good crops, there did not occur the usual rush of applications which generally occur during the months of August and September. In the past few years it has been very noticeable how crop failures and irrigation applications have coincided. Some farmers have pointed out that the fact of a wet year producing good crops ought to be one of the strongest arguments in favour of irrigation, because it demonstrates that moisture is the one factor needed in a dry year, but this does not appear to influence many of those in a position to construct irrigation schemes. Owing to the almost complete cessation of railway building and municipal enterprise, the number of industrial and municipal schemes inspected continued small."

Saskatchewan Special Inspections District.—Last season this district comprised all of the province of Saskatchewan exclusive of the East Cypress Hills district, and in addition the easterly seven ranges in Alberta north of township 13. The work in the district proved very light, and the services of the engineer in charge for the period June 16 to September 23 were utilized in assisting with the special investigational work on the northern tributaries of the Milk river

in connection with the International Waterways Treaty. The field inspections in this district occupied the time of the engineer in charge from the 1st of May to the 23rd of October, exclusive of the period above mentioned spent on other work. During this time 38 inspections and 15 surveys were made.

The following quotations from the inspector's annual report briefly summarize the conditions with respect to inspection work as compared with previous years: "There was a considerable falling off in the number of applications received for new schemes as well as inspections of existing ones compared to last year, the numbers being 38 in 1923 against 59 in 1922, although there was an increase in the number of applications for irrigation schemes. The number of industrial and domestic applications decreased nearly two-thirds from last year's record and the municipal and "other" applications were practically the same. The industrial applications from now on will be for additional supplies on lines with heavy traffic, or new lines opened up, the majority coming in from the Canadian National Railway. The Provincial Government has also made application for nearly all the schemes it had an interest in on behalf of different municipalities. However, since the season was one of heavy precipitation compared to previous years, the decrease in the number of applications was expected."

Irrigation Projects

THE CANADIAN PACIFIC RAILWAY COMPANY

Western Section.—This project has now been in operation 16 years; it has a total classified irrigable area of 218,980 acres. The past season has been ideal for crop production, and after six comparatively dry years it can reasonably be classed as a wet season. The rains came at the most opportune times for maximum crop production. The fact is made particularly evident from the report of the company's grain survey, which gives an estimate of 10,050,000 bushels of wheat from the total area cultivated, equal to an average per acre yield of 35 bushels. Owing to the favourable moisture conditions only 3,074 acres were irrigated and this mostly for alfalfa and meadow grasses. Many of the wheat crops on summer fallow produced from 40 to 60 bushels, and oats under similar conditions went as high as 130 bushels per acre. Of the total wheat crop produced 4,725,000 bushels were taken from water-right land. The total value of crops produced on water-right land has been estimated at $3,838,000, an increase of some $2,000,000 over 1922. The farmers in this section are nearly all engaged in straight grain farming. The market value per bushel of the various grain crops produced was as follows:—wheat 70 cents, oats 25 cents, barley 35 cents, flax $1.70, potatoes 50 cents per bushel. Of the fodder crops the per ton value was:—hay $12, green feed $5, sunflowers for silage $3. Hail unfortunately did considerable damage in some parts of the districts. The area under this project was, however, entirely free from the grasshopper pest and from the hot drying winds so often experienced during the month of June. During the growing season, i.e., from April 1 to August 31, 14.83 inches of rainfall was received at Strathmore and recorded by months as follows:—April 1.06 inches, May 3.97 inches, June 4.02 inches, July 2.56 inches, August 1.98 inches. The frost-free period extended for 130 days.

A generous program of maintenance work has been carried out during the past year. Twenty-two and a half miles of ditches were cleaned out by teams and 228 miles by means of mechanical excavators. A large number of structures have been reconstructed or reconditioned, and includes 341 delivery gates, 51 culverts, 39 bridges, 21 holdup and bank gates, 1,125 small timber drops and 16,780 linear feet of timber flumes. A new reinforced concrete holdup and spillway gate has been constructed on Secondary Canal "A" at the head of Twelve Mile Coulee spillway. Revisions have also been made to several of the small distributary systems in the Cairnhill and Mewasin district. No new settlement has been reported for this district during the past year.

Eastern Section.—This project has now been in operation some ten years, and has a total irrigable area of some 400,000 acres, of which 124,000 acres have already been sold. The general situation, however, in this district is not quite so encouraging as in the Western Section. With a much lower precipitation and with slightly higher average temperatures irrigation becomes more essential for profitable farming. The area actually irrigated during the past season was 42,928 acres, as compared with 93,375 acres in 1922, a decrease of 50,447 acres. The yields for the various grain crops do not compare favourably with those of the Western Section, where almost sufficient moisture was received in the form of rainfall to ensure very generous returns. The principal irrigated crop was wheat, which represented approximately 45 per cent of the total crop area. The price per bushel for "number one hard" in this district was, however, only 71 cents as compared with 80 cents per bushel in 1922, 92 cents in 1921 and $1.90 in 1920. The average value of yields from irrigated lands amounted to $17.09 per acre and from non-irrigated lands $11.83.

The farmers in this section have not yet realized, that unless their crops are kept supplied with sufficient moisture to satisfy their requirements during the growing season, they cannot obtain yields which will be sufficient to meet their expenses. The system of gaining experience by experimenting is extremely costly, and has, in some cases, been so discouraging that the settler has abandoned his land. A census of the yields obtained, and the water used by a group of ten farmers in this district during the past season clearly illustrated the condition. On these ten farms the average yield of wheat was 19½ bushels per acre with only one irrigation, which corresponds very closely with yields obtained at the Experimental Station at Brooks under similar soil and climatic conditions with a 4-inch application of water plus rainfall. But with two 4-inch irrigations the yields received were from 30 to 35 bushels, and with three 4-inch irrigations they were as high as 43 bushels per acre. This condition indicates that the value and importance of frequent applications of water during the growing season is not yet fully understood or the gains, which are made possible, realized.

The company has again expended large sums of money on repairs, betterments and renewals.

No new settlers have come into the district during the past year. A few settlers have, however, moved out for various reasons,—generally attributed to inexperience or unsuitability.

There were 124 days free from damaging frost in this district during the year,—from May 16 to September 16. The total precipitation at Brooks for the twelve months was 11.24 inches, of which 9.67 inches fell during the growing season, made up as follows: April 0.50 inch; May 0.64 inch; June 4.32 inches; July 2.10 inches; August 2.01 inches; September 0.10 inch.

There has been very little change in the livestock situation during the year and prices have remained low. A slight increase in the number of sheep and a decrease in the number of poultry have been reported.

An interesting and valuable move has been made by the farmers in this section during the past year in the organization of the Grimm Alfalfa Seed Growers Association of Alberta, Limited. This is purely a farmer's co-operative association. and consists of over one hundred growers, each of whom holds one share in the association. This has been legally incorporated under the "Co-operative Societies Act" of Alberta, and is empowered to own property, buy and sell seed, borrow money, etc. Under the 5 year contract which each farmer in the association enters into, he agrees to deliver all his alfalfa seed to the association, which cleans, grades and sells it for him. The seed cleaning plant which has been erected at Brooks consists of the largest size Clipper mill procurable, an Eddy centrifugal cleaner, an Eddy whizzer, a dryer and a large size Johnson scarifier; the whole is housed in a building 60 by 40 feet.

Lethbridge Section.—The area under water-agreement in this section is 77,162 acres. A large percentage of the land lying below the canals is under cultivation. The total area irrigated during the season was 72,345 acres, as compared with 75,558 acres in 1922, being a decrease of 3,213 acres. The average per acre value of the crops raised on the irrigated lands in this district was $18.81, as compared with $23.07 in 1922, a decrease of $4.26. The average per acre value of the crops raised on the non-irrigated lands in this district was $16.30. The total value of the various crops grown on the irrigated lands during the season has been estimated at $1,026,925 and at $277,709 from the non-irrigated lands. There were 937 actual users of water during the season.

The ground was very dry in the early spring and until the end of April the precipitation was slightly below normal. The May rains came along at beneficial intervals and created an ideal seed bed. In the two succeeding months the rainfall was such, that for grain crops, there was very little call for irrigation. The rainfall at Lethbridge in inches, during the season, was as follows: April 1.09, May 3.48, June 4.45, July 2.55, August 1.01, September 0.18, equal to 12.76 inches, the total for the year being 16.40 inches. The period free from damaging frosts extended from May 3 to September 22, equal to 143 days. The weather remained mild until late in the fall with very little precipitation. Severe hail storms passed over the district during the summer and caused considerable damage. Very little damage resulted from high winds and the grasshoppers which have given a great deal of trouble during the past two or three years did but little damage.

Very little new construction has been carried out during the year. Improvements were made to a number of existing structures and 19 small structures were renewed. An "Austin" drag-line excavator was used for cleaning out silt and raising the banks of the north lateral. On lateral number one a "Bay City" dredge was used for similar work. On the main canal near Kimball an old "Marion" dredge which had not been operated since 1908 was again put into service, and removed some 64,000 cubic yards of material from this section of the canal. This work considerably improved and enlarged the canal section and strengthened the banks.

TABER IRRIGATION DISTRICT

This has been the third year of farming under irrigation conditions for this district. Owing to a fairly generous rainfall during the growing season very little use was made of the water. A record of the monthly quantities delivered to the headgates of the system shows that for the month of June only, 2,182 acre-feet were received, whereas during September and October 6,569 acre-feet were delivered and used for fall irrigation.

The first stream for irrigation was turned into the system on the 21st of May. Of the 17,244 irrigable acres in the district only 3,625 or 21.3 per cent of the area was actually irrigated. Of this area only 1,400 acres were irrigated during the summer, the balance being fall irrigated. The operation of the system was again very successfully carried out by the manager and two assistants. Owing to the frequent local showers during June and July there was only a light demand for water, and this was principally for irrigating alfalfa. Harvest operations taking somewhat longer this year, fall irrigation was not commenced until the 18th of September, after which date the demand gradually increased, but at no time was the canal operated at more than two-thirds capacity. Water was shut off on the 29th of October owing to ice conditions in the canals.

The financial condition of this district remains satisfactory. The surplus funds have now amounted to $29,507.82, an increase of $7,933.48 over the previous year. The Board of Trustees after considering various sinking fund investments, recently decided to endeavour to purchase their own district bonds. These are 30-year bonds in $1,000 issues, bearing interest at the rate

of 6 per cent annually, and held by the Canadian Pacific Railway Company. This company consented to the proposal and decided to release them at par. It was, however, decided to defer utilizing this surplus until 1923. It was felt that a reduction of 50 cents in the 1924 assessment, which would absorb some $8,000 of the surplus, would be more helpful to the farmers at this time.

CANADA LAND AND IRRIGATION COMPANY

This has again been a good year for the farmers under this project, the crops harvested being above the average. Weather conditions were particularly favourable, the precipitation during the growing season being well distributed. The records of rainfall in inches at Vauxhall from May to September were:—May 1.65, June 5.96, July 2.85, August 1.74, September 0.11, a total for the period of 12.31 inches. The frost-free period extended from May 28 to September 10 or 105 days, as compared with 136 days in 1922. The climatic conditions throughout the whole district were particularly favourable, there being very little wind and sufficient rainfall to raise a good crop on dry land. On the irrigated lands there were 10,373 acres cropped, of which it was only necessary to irrigate 6,815 acres. Of the total cropped area 4,965 acres were seeded to wheat and yielded an average of 26.35 bushels per acre. At an average price of 70c. per bushel this crop realized $91,585 equal to a per acre value of $18.44. The second largest acreage was alfalfa hay with 1,463 acres yielding 4,390 tons or an average of 3 tons per acre. At an average market price of $8 per ton, this crop, therefore, represented a per acre return of $24 or a total of $35,120. The area seeded to potatoes was only 86 acres this year and the average per acre yield was 219 bushels. The prevailing market price averaged 51c. per bushel, representing a per acre return of $111.70. The total estimated value of the crops grown on the 9,647 acres which were recorded was $196,916.25 which represents an average per acre return of $20.41, as compared with $27.73 in 1922, $23.80 in 1921 and $30.86 in 1920.

LETHBRIDGE NORTHERN IRRIGATION DISTRICT

The construction of this project was completed about the end of May, 1923, and the official opening was announced to take place at Keho Lake reservoir on Saturday, June 16. Unfortunately an unprecedented flood in the Oldman river on June 1 and 2 caused such serious damage to the headworks, to the first one and one-half miles of the main canal, and to the flume across the Oldman river that the opening ceremony was indefinitely postponed. The damage thus created was not repaired until September 30. Water was again turned into the system on October 3 and authority was given to divert until the 15th. Owing to an exceptionally open fall, and the urgent requests of the farmers for water for fall irrigation and stock-watering ponds, the system was operated until October 29. The total cost of repairs necessary to restore the works and render them safe for operation was $81,500. The total amount expended on construction to December 31, 1923, was $4,097,614. The number of acres irrigable in the district is 104,846. The area actually irrigated during the past season was 6,963 acres.

An active land settlement campaign is being conducted by the Irrigation Council of Alberta with a view to assisting the farmers to dispose of their surplus irrigated lands. Agents have been sent to Europe and good progress is being reported.

UNITED IRRIGATION DISTRICT

Construction work on this project was completed during the early part of August, 1923, and a final inspection of the works made during the same month. An additional area of 2,163 irrigable acres has been taken into the district during the past year, and a court of revision under the provisions of the

Irrigation Districts Act of Alberta is to be held in the near future. This court of revision will deal with all the lands in the district which have been affected by the reclassification survey. The original estimated irrigable area in the United District was 23,093 acres, whereas under the reclassification this area will be increased to 33,995 acres and including the extension the total irrigable area will be 36,158 irrigable acres. The district's bond issue was $550,000, and there has been expended up to December 31, 1923, $417,184 on construction. The yearly statement shows a very satisfactory condition with a considerable bank balance at the close of the year. Water was turned into the system on July 17 for the purpose of priming canals and puddling structures. Favourable weather conditions prevailed during the month of October and 3,000 acres of stubble and summer-fallowed land were fall irrigated.

NEW WEST IRRIGATION DISTRICT

The necessary works in connection with this district were constructed during the summer, the earth-work being let in small contracts to the resident farmers. Good progress was made and the entire excavation work was completed by the end of July. Construction of the necessary timber structures was carried out at the same time and the whole system completed by the middle of August. The total cost of excavation for the distributing system was $12,301, representing 65,645 cubic yards at 18¾ cents per cubic yard. This cost included the necessary culverts and fencing. In the timber structures 169,235 feet board measure of lumber were installed at a cost of $79.40 per thousand, representing a total expenditure of $13,437. Some water was turned into part of the system early in July but very little was used for irrigation purposes as the district was favoured with generous rains at beneficial intervals. Although good crops were harvested without irrigation, most of them would have been greatly benefited, and yields increased had some additional moisture been applied when the grain was heading out. The farmers in this district are not familiar with irrigation, and without some practical demonstrations or some instruction in the most economical methods of land preparation, application of water, and crop rotation, the process of development from dry to irrigation farming methods is bound to be slow.

There are 4,500 irrigable acres in the district, 21 miles of constructed canal and 29 water-users. During the past year only 40 acres were actually irrigated,—mostly in the fall for the 1924 crop. The bonded indebtedness on the 31st of December, 1923, was $209,500 which represents a per acre charge of $46.55. The following trustees are at present representing the district:—Mr. Percy Love, chairman; Mr. Charles Watterburg, secretary, and Mr. C. W. Gray, trustee.

The water supply is obtained from the Bow river, and is diverted through the works of the Canada Land and Irrigation Company. The point of diversion from the company's main canal is on the NE.¼ of section 36, township 13, range 17, west of the 4th meridian.

LITTLE BOW IRRIGATION DISTRICT

Construction of the headworks and necessary river protecting work in connection with this project was undertaken during the winter of 1922-23. The excavation of the section of canal to connect with the channel of the Little Bow river was built during the spring and summer. Water was first turned into the system from the Highwood river on the 6th of September and a thorough test of the works made and canal capacity tested.

On June 1 an exceptional flood in the Highwood river caused some damage to a portion of the headworks. The concrete slab protecting the embankment on the downstream side of the headgates was partly destroyed. The whole of the diversion headworks was completely submerged for a period during the

peak of the flood. Some damage was caused to the partially constructed canal and a great deal of silt deposited. A bank of gravel and silt was also deposited in front of the headgates—high enough to entirely cut off the supply at low-water stage of flow.

The 50 cubic feet per second from the Highwood river originally licensed to the Government of the province of Alberta for the domestic and stock-watering requirements of the settlers along the Little Bow river, will now, by arrangement with the district be diverted through these works.

Although the diversion works of this project are now complete, and water can be diverted into the Little Bow river, none of the individual irrigation schemes have been constructed. The past season was the first for several years that the farmers of this new district received sufficient rainfall to ensure a crop. Their whole efforts were, therefore, centred upon making the most of these favourable conditions, and consequently decided to suspend any work entailing further financial outlay until after their harvest had been assured. It is fully anticipated that the majority of these individual pumping schemes will be installed before the coming summer.

MOUNTAIN VIEW IRRIGATION DISTRICT

A petition for the formation of this district was made to the Provincial Government on the 3rd of March, 1922. A reconnaissance survey was made by the Reclamation Service during the season of 1922, and the project was found feasible for the diversion of water from the Belly river on the SW. $\frac{1}{4}$ of section 33, township 1, range 28, west of the 4th meridian, for the irrigation of 2,500 acres. Notice of the petition for the formation of the district under the provisions of the "Irrigation Districts Act" was published in the *Alberta Gazette* of April 30, 1923. An allocation of 4,000 acre-feet for the district was made by the Minister of the Interior from the Belly river and memorials and plans approved. The official order for the formation of the district and the appointment of the three trustees was published in the *Alberta Gazette* of August 15, 1923. This project is now under construction.

SOUTH MACLEOD IRRIGATION DISTRICT

Further progress in connection with the construction and development of this project is being held in abeyance by the provincial authorities until the surplus irrigated lands in the districts already constructed have been settled. No effort has been made by the district officials to finance the district without a provincial guarantee.

MEDICINE HAT EASTERN IRRIGATION DISTRICT

It was pointed out in last year's report on this project that as the Provincial Government declined to pledge the credit of the province for the security of the district's bonds, the district should be given an opportunity to obtain outside financial assistance. It was, therefore, decided to allow a reasonable period to elapse before taking steps towards cancellation of the water reservation. In May, 1923, at the special request of the trustees of the district an extension of six months was granted in which to afford an opportunity for a further investigation by the responsible provincial minister. In July, 1923, after inspecting some of the lands affected, the minister expressed his willingness to present to the government of the province the request of the parties interested, for a guarantee of debentures for either the Bullshead Creek or the Ross Creek section of this project, purely for experimental purposes. It was ultimately decided that the Bullshead Creek section of the project should be the one to be recommended for assistance. It is not probable that any action will be taken towards the development of the Ross Creek portion of the project until the results of the experiment on the Bullshead Creek section have

been studied. Under the circumstances, and owing to the fact that other applications for water on Ross creek were being held in abeyance, the district's reservation of this source of supply was recommended for cancellation. In fairness to those of the original petitioners whose lands were to be served by the development of the Ross Creek section, it has been provided, that before cancellation be made effective, an investigation shall be made to ascertain the economic feasibility of developing individual schemes.

As the lands included in the original Bullshead Creek project were mostly held by non-residents and were generally unoccupied and undeveloped, the resident owners on adjacent lands asked the department to make a further investigation with a view to the inclusion of their lands. A new survey was made, and it was ascertained that lands lying to the north of those originally included in the district and held by resident owners, could be economically served. A petition for change of content under Section 161 of the Irrigation Districts Act of Alberta was, therefore, circulated and the necessary percentage of withdrawals, to comply with the provisions of the Act, obtained. As soon as the other requirements of the Irrigation Districts Act have been complied with, a recommendation for the consent of the Minister of the Interior for the necessary amendment to the original reservation of water will be made.

MEDICINE HAT SOUTHERN IRRIGATION DISTRICT

Some further surveys and studies regarding the reservoir possibilities in the Sevenpersons drainage basin were made during the early part of the year. From these studies it was ascertained that a storage reservoir of 13,200 acre-feet could be created in Robinson valley at an estimated cost of $6.21 per acre-foot stored. The total cost of this proposed project, including construction of diversion headworks, carriage canals, organizing expenses, interest charges, engineering and contingencies was found to amount to $130,560 which worked out at $43.52 per irrigable acre. This estimated cost for a partial duty scheme, which would furnish a depth of from 14 to 18 inches of water on the land, in seven out of nine years, might have been considered satisfactory under certain conditions. In this particular case, however, it was found that the proposed Robinson Valley reservoir would inundate 1,787 acres of fair natural hay lands, and would seriously affect 800 acres of very valuable naturally flooded hay lands. In all, 2,587 acres of productive lands would be rendered practically valueless in order to benefit only 3,000 acres of arable land lying further to the northeast. Furthermore, the owners of the hay lands affected intimated they would strenuously oppose any scheme which would deprive them of the benefits which their lands now receive from natural flooding. It was, therefore, considered that the scheme was neither economically feasible nor justifiable and the application was duly cancelled. As nine subsequent applications have been received from private individuals to develop small irrigation schemes from the available waters of this drainage basin, it would appear, that the water will be put to beneficial use in the near future by the owners of riparian lands.

ROBSART-VIDORA IRRIGATION DISTRICT

The application for the formation of this district was published in the *Saskatchewan Gazette* of June 15, 1923. By a vote taken on October 13, 1923, the electors declared themselves unanimously in favour of irrigation. The necessary ministerial order for the erection of the district, giving its name, content, date and place of election, and the names of the trustees was promulgated on December 5, 1923, and appeared in the *Saskatchewan Gazette* on December 31, 1923.

Proposed Irrigation Districts

LETHBRIDGE SOUTHEASTERN PROJECT

A full description of this project accompanied by maps and cost estimates was published in the annual report for the year 1921-22. A further report dealing with a number of extensions and revisions also accompanied by a revised estimate of cost was published in the annual report for the year 1922-23. In his report on this project Mr. D. W. Hays, who was employed by the Dominion Government in the capacity of consulting engineer, pointed out the advisability of investigating the possibilities of storing water on the Milk river in Canada for the purpose of conserving Canada's share of the flow of that stream and suggested a site in township 2, ranges 18 and 19, west of the 4th meridian. A survey was made of this site during the past year. A complete plane-table survey was made of both the north and south forks between the elevations of 3,520 and 3,630 feet, and a number of cross-sections made of possible sites for a dam. This survey was commenced on November 27 and completed on December 22. During this period the party plane-tabled 4,000 acres of the valley.

This site could be developed to a capacity of 153,850 acre-feet at a full supply elevation of 3,630 feet. At this capacity the superficial area would be 3,913 acres, and a dam of 1,250 feet crest length with a maximum height of 110 feet would be required. From a study of the water supply of the Milk river it is considered that a capacity of 30,000 acre-feet would be the most economical development, and the design of dam and cost estimates have been based on this. The superficial area at this capacity is 1,347 acres, the crest length of dam 960 feet and the maximum height 67 feet. The estimated cost of the proposed development up to 30,000 acre-feet is $343,646 or at the rate of $11.45 per acre-foot.

It is proposed to incorporate this reservoir in the development of a project to irrigate 17,000 acres in the Warner district. Plans and estimates have been prepared for this scheme and are referred to under separate heading.

Certain areas included in the Lethbridge Southeastern project have been formed into districts, but very little progress has been made with the organization during the past year.

THE SOUTHERN IRRIGATION DISTRICT

The order for the erection of this district was published in the *Alberta Gazette* on March 31, 1920. No progress was made, however, on account of the difficulty of procuring a water supply, except as a part of the Lethbridge Southeastern project. When, however, by an order of the International Waterways Commission, dated October 4, 1921, a definite apportionment of the waters of the St. Mary river between the United States and Canada was effected, a tentative agreement was reached between the Canadian Pacific Railway Company and the farmers of this district, whereby the company would sell to new districts 100 second-feet or less at $4,000 per second-foot to be delivered by the company into the ditches of the districts. The company also agreed to make a charge of $112.50 per second-foot for maintenance and operation, the new districts to take over all old water-users, and pay to the company 66 per cent of the amount collected under the existing agreements.

Petitions have been submitted to the Minister of Railways and Telephones of the province for the withdrawal of certain lands in the Southern Irrigation district, and also for the erection of the proposed Magrath and Raymond districts with a view to procuring a water supply from the Canadian Pacific Railway Company and constructing a system of canals to supply the lands with water.

THE PROPOSED MAGRATH DISTRICT

It was originally the intention to form into a district all irrigable lands to the west of Pothole coulee in townships 5, 6 and 7, ranges 21, 22 and 23, and petitions for the erection of this proposed district were submitted to the Minister of Railways and Telephones of the province. Before further action could be taken, however, it was necessary to investigate the possibilities of including certain lands in townships 4 and 5, ranges 22 and 23, south of the main canal of the Alberta Railway and Irrigation Company, which the owners were desirous of having included. A survey was accordingly made of these lands, and it was detremined quite feasible to reach them from a lateral taking out of the main canal of the Alberta Railway and Irrigation Company's system just above the town of Spring Coulee. The estimated irrigable area under this or the area for which petitions have been submitted is 2,442 acres. It is probable that a petition for the erection of a district composed of these lands will be submitted to the Minister of Railways and Telephones of the province and that this scheme will be constructed in the near future.

THE PROPOSED RAYMOND DISTRICT

It is proposed to form into a district those lands in township 6, ranges 19, 20 and 21, under the Raymond and Stirling lateral of the Alberta Railway and Irrigation Company which require an additional water-supply. A petition for the exclusion of all such lands from the southern district has been submitted to the Minister of Railways and Telephones of the province and also a petition for the erection of the Raymond district.

THE PROPOSED WARNER DISTRICT

A petition for the erection of this district was submitted to the Minister of Railways and Telephones of the province on February 20, 1920, but no progress has been made since that time.

The construction of the proposed reservoir at the Milk River forks would create the necessary water-supply for about 17,000 acres in this district. Plans have been prepared of a scheme to irrigate this area from Milk river and cost estimates completed. The plan of development contemplates the use of the Old Milk River diversion canal constructed years ago by the Alberta Railway and Irrigation Company. It is estimated that the reconstruction of this canal will cost $106,850. The irrigable area which it is proposed to serve is in townships 3 and 4, ranges 16, 17 and 18, west of the 4th meridian. The lands are rolling but have a good general slope toward the northeast. The tract is exceptionally well served with natural watercourses draining to Verdigris coulee, and the district has been reported as generally free from alkali.

The estimated cost of the proposed scheme is $629,419 which is at the rate of $37 per irrigable acre. This cost, however, does not provide for leasing or otherwise procuring the right to the use of the old Milk River canal from the Canadian Pacific Railway Company. A general plan of this scheme is shown on plate 13.

OTHER PROPOSED DISTRICTS IN THE LETHBRIDGE SOUTHEASTERN PROJECT

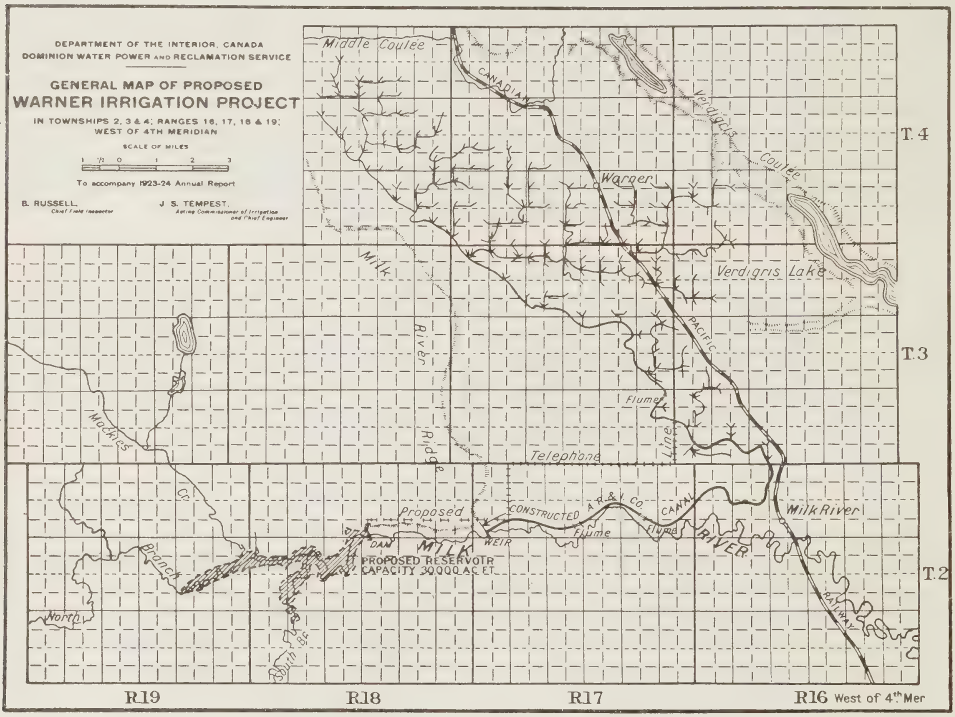
The other districts which have been proposed are the New Dayton and Masinasin. No progress has been made with these districts during the past year. The lands included can be irrigated only as a part of the Lethbridge Southeastern project.

RETLAW-LOMOND IRRIGATION DISTRICT

Full reports of this district have been submitted, and will be found in the annual reports of the department for the years 1914, 1918-19 and 1919-20.

During the year 1922-23 plane-table surveys were completed of the whole project. Field work was commenced on May 10 and completed December 2, 1922. The total number of plane-table days in this period was 752, in which

PLATE 13



time 227,730 acres were plane-tabled and classified. Besides this work 750 miles of levels were run and 129 soil samples procured and tested.

Designs and cost estimates have since been completed for two alternative schemes to supply the project with water.

First—An extension of the canal system of the Lethbridge Northern Irrigation district.

Second—An extension of the canal system of the Canada Land and Irrigation Company.

Description of Lands.—Lands in this project extend easterly to the limits of the Canada Land and Irrigation Company's tract and westerly to the Little Bow river and Buffalo hills. To the south they extend to the Oldman river and to the north to the Bow river. The general slope is toward the southeast and the principal topographical features consist of two wide depressions which traverse the area in a north and south direction. The irrigable lands lie along the slopes of these depressions which form the main drainage of the district. These depressions, however, do not form continuous channels by which waste water would immediately be carried off to the rivers, but the beds consist of a number of old lake bottoms with ridges or saddles between. One of these

depressions heads in section 33, township 13, range 19, and runs southerly to a lake bottom in sections 28 and 29, township 13, range 19, thence southerly to a second lake bottom in sections 16 and 17, township 13, range 19, and finally in a southeasterly direction to a third lake bottom in section 13, township 12, range 19. From this point it runs in a northeasterly direction to section 22, township 17, range 18, where it empties into the Deadhorse coulee. This depression forms the natural drainage of most of the lands to the south of the main canal of the Canada Land and Irrigation Company.

A. second depression heads at Badger lake in sections 31 and 32, township 16, range 18, and runs southerly to a lake bottom in section 32, township 15, range 18. There is a height of land in this depression in section 19, township 16, range 18. From section 32, township 15, range 18, the depression continues southerly to a second lake bottom in section 20, township 15, range 18, and thence southeasterly to a third lake bottom in section 3, township 15, range 18. From here it drains in a southeasterly direction to Lost lake.

It is estimated that under the first alternative the total number of acres which can be irrigated is 64,184, while under the second the total number of acres which can be irrigated is 55,513. The additional lands which can be irrigated from the first alternative are mostly in the Sundial district in townships 12 and 13, ranges 19 and 20, and include some of the best lands in the project. From the surveys made it was found impossible to reach these lands from an extension of the canals of the Canada Land and Irrigation Company. Considerable areas are very flat and although not particularly rough to the eye, have so little slope that only a small percentage consisting of the lower swales can be irrigated. The east half of township 12, range 17, has so little slope that it is practically all non-irrigable. A considerable area to the west of Traverse is rough and not suitable for irrigation while lands to the north of the main canal of the Canada Land and Irrigation Company in townships 13 and 14, ranges 18, 19 and 20 are very rolling. The best lands in the project are in townships 10, 11 and 12, range 17. Lands in townships 16, 17 and 18, ranges 18 and 19 are only fair.

Drainage.—During the year 1919 a fairly elaborate system of drainage canals was outlined. This scheme necessitates the construction of a great many miles of drainage canals throughout the two depressions referred to which would finally dispose of the waste water in the Oldman river. Such a scheme would be very expensive and add greatly to the total cost of the project, and it would seem upon a further study of the topography that much of this scheme can be elimated by allowing the waste water to accumulate in a number of sumps or lake bottoms where it would be taken care of by evaporation.

"B" Drainage.—The natural outlet for waste water from most of the lands to the north of the main canal of the Canada Land and Irrigation Company is to Lost lake, a large shallow slough in township 14, range 17, west of the 4th meridian. It is proposed to allow the run-off from this area to accumulate in this lake when it will be disposed of by evaporation. The area of Lost lake below an elevation of 2,560 feet is 750 acres, and although the actual depth is not known it can be safely assumed that the average depth below the 2,560 contour is at least 2 feet, making the capacity 1,500 acre-feet. The area which will drain to this lake is 26,000 acres, and assuming that the run-off will be six per cent of the total quantity of water applied to the land, the following table shows the disposition of the waste water from this area.

Area of lake—750 acres.
Maximum capacity—1,500 acre-feet.
Maximum depth—2 feet—assumed.

Drainage "B"—Table Showing Run-off to Lost Lake and Evaporation Losses

	Approximation	Approximation	6 p.c. Run-off	Rate of Evaporation	Evaporation in Ac. ft.	Water in Lake at end of Month
	Inches	Ac. ft.		Feet		Ac. ft.
May	2	4,300	260	0·5	375	0
June	6	13,000	780	0·7	530	250
July	6	13,000	780	0·9	670	360
August	2	4,300	260	1·0	750	0
September	2	4,300	260	0·5	375	0
October	....	....	....	0·4	300	0
November	....	....	....	0·2	150	0
December	....	....	....	0·2	150	0
January	....	....	....	0·2	150	0
February	....	....	....	0·2	150	0
March	....	....	....	0·2	150	0
April	....	....	....	0·4	300	0

Evaporation losses based on the maximum area of 750 acres.

"A" Drainage.—The total irrigable area to the south of the main canal of the Canada Land and Irrigation Company under the first alternative is 25,207 acres. About 12,720 acres of this area are on slopes which drain off directly to the Little Bow and Oldman rivers. The remaining 12,487 acres will drain into depressions which have no outlets. It is proposed to fill up these sloughs as follows:—

Location of Slough Sec.	Tp.	Rge.	Approximate Area Acres	Approximate Capacity Acre feet	Full Supply Level Feet
28–29	13	19	210	720	2,690
8–9–17–16	13	19	115	210	2,685
3–4–9–10	13	19	150	370	2,685
35	12	19	40	50	2,684
25–26......	12	19	40	100	2,675
13	12	19	35	50	2,673
Total			590	1,500	

Annual evaporation from sloughs will be, say	7,500 ac. ft.
6 p.c. run-off from 12,487 acres " "	900 "
Surplus capacity	6,600 "

Although this capacity is much greater than required, it is not possible to ensure that any part of the area (590 acres) will not be flooded without undue expenditure on ditch construction. It is more economical to purchase the whole area than attempt to drain a portion of it by heavy cutting. The only construction required for the above scheme is a 2-foot ditch 9,000 feet in length between the sloughs in sections 26 and 35, township 12, range 19.

Soil.—The soil consists generally of a sandy loam, the subsoil being sand silt or clay. Out of 176 groups of soil samples tested some 58.5 per cent represent negligible or weak alkali to a depth of at least 5 feet; 28 per cent contain no alkali to a depth of 3 feet; 11.5 per cent contain no alkali to a depth of at least $1\frac{1}{2}$ feet. Thus 98 per cent of the soil groups contain less than the acknowledged limit of alkali while 2 per cent contain alkali to a dangerous degree.

Water-supply, Oldman River.—Studies of the available water supply from this stream have been made in previous years in connection with the Lethbridge Northern district and the proposed Retlaw-Lomond extension. It has been determined that in order to irrigate any considerable area of land in addition to the Lethbridge Northern district, storage is required. The following is an estimate of the storage capacity available:—

Keho lake, tp. 11, rges. 22-23, W. 4th Mer.	41,000	ac.-ft.
Gap reservoir, tp. 10, rge. 3, W. 5th Mer.	90,000	"
Castle River reservoir, tp. 6, rges. 2-3, W. 5th Mer.	30,000	"
Canyon, creek tp. 6, rge. 2, W. 5th Mer.	40,000	"
Total	201,000	"

The 41,000 acre-feet in Keho lake is used to irrigate the lands of the Lethbridge Northern district, the remaining 160,000 acre-feet are available for other lands. With this storage the water-supply of the Oldman river is considered adequate for an area of approximately 160,000 acres in addition to the Lethbridge Northern district.

The estimated area which can be irrigated by an extension of the Lethbridge Northern district is 64,184 acres, making the combined area 169,184 acres. Assuming absorption losses of 30 per cent at the headworks of the Lethbridge Northern project, and an irrigation factor of 80 per cent, the requirements would be as follows:—

May	32,000	acre-feet
June	97,000	"
July	97,000	"
August	32,000	"
September	32,000	"
Total	290,000	"

In order to maintain this supply from the Oldman river during years of minimum flow, storage approximately 47,000 acre-feet net at intake is required in addition to the 41,000 acre-feet in Keho lake. Allowing 10 per cent losses for transportation from the reservoir to the intake, the gross storage capacity required is 52,000 acre-feet. To provide adequately for riparian and other prior rights it would be advisable to develop the Castle river and Canyon Creek reservoirs, the combined capacity of which is 70,000 acre-feet.

Water-Supply, Bow River.—A very detailed study of the Bow River water supply has been made which deals particularly with the possibilities of developing the proposed Champion and Retlaw-Lomond Irrigation districts. Although on account of the very large proportion already made to the Canadian Pacific Railway Company and the Canada Land and Irrigation Company, the available water-supply from this source is more uncertain than from the Oldman river, it is estimated that by utilizing the flood waters there is a sufficient supply for 90,000 to 100,000 acres in the proposed Retlaw-Lomond district, and 60,000 acres in the proposed Champion Irrigation district.

The estimated area which can be irrigated by an extension of the canals of the Canada Land and Irrigation Company is 55,514 acres. The estimated irrigable area in this proposed project itself is 203,000 acres, making a total combined irrigable area of 258,514 acres. The following storage has already been or will be developed for the lands of the Canada Land and Irrigation Company:—

Lake McGregor reservoir	300,000	ac.-ft.
Little Bow reservoir	30,000	"
Total	330,000	"

The ultimate capacity estimated by the company for the supply canal from the Bow river to lake McGregor is 1,200 second-feet. During the year 1921 a study was made of the canal system of the Canada Land Company's system for the purpose of determining the cost of enlargement to include the lands of the proposed Retlaw-Lomond district. It was estimated that in order to irrigate some 100,000 acres in the proposed Retlaw-Lomond district it would be necessary to increase the main supply canal to 2,400 second-feet, and the Lake McGregor reservoir to approximately 500,000 acre-feet. A revision of this estimate based on an irrigable area of 55,514 acres forms part of this report. The required canal capacity has been revised to a capacity of 1,755 second-feet and the storage capacity to 400,000 acre-feet. These capacities are considered ample to provide for the additional area in the proposed Retlaw-Lomond project.

Canal Design.—The main and branch canals have been designed for a maximum requirement to serve 50 per cent of the total area with 6 inches of water in a period of 15 days. Absorption losses have been estimated at the rate of 6 second-feet per million square feet of wetted area. A co-efficient of roughness "N" equal to 0.025 was allowed for all canals of bed-width of 16 feet or less and 0.0225 for canals of greater bed-width. Grades were used limiting the velocities in canals from 1 to 3 feet per second.

Extension of Lethbridge Northern Canals.—The proposed point of diversion from the canal system of the Lethbridge Northern project is from the Albion Ridge branch in the SE. ¼ section 31, township 11, range 21, and it is proposed to enlarge this branch from Keho lake to the above point by 780 second-feet. From here the water will be turned into a natural watercourse and dropped down to the NE. corner of section 36, township 11, range 21. The total fall in this watercourse is 249 feet, and it is proposed to construct concrete drops for the greater portion of this fall. From this point to the SW. ¼ of section 15, township 13, range 20, where the south branch takes off, the canal has been designed to carry 777 second-feet as far as the Little Bow crossing, and 735 second-feet from there to the division gates at the south branch. The valley of the Little Bow river is crossed in sections 8 and 16, township 13, range 20, by means of an inverted syphon consisting of a single steel pipe ten feet in diameter carried on concrete supports spaced at sixty-foot centres. The total length of the syphon will be 5,925 feet and the maximum pressure head 230 feet. From diversion gates in the SW. ¼ of section 15, township 13, range 20, the main canal runs in a northerly direction, crossing over the main canal of the Canada Land and Irrigation Company just west of the Little Bow reservoir in section 29, township 14, range 20.

For this crossing it is proposed to construct a 9.5 by 4.66-foot flume 90 feet in length. The main canal carries the supply for 5,297 acres to the south of the main canal of the Canada Land and Irrigation Company, and 38,986 acres to the north of this canal. Its capacity at a point in section 33, township 14, range 20, where the south lateral takes off is 436 second-feet. From this point north it follows the slope of the Buffalo hills. A railway-crossing is required in section 36, township 15, range 20, west of the 4th meridian, and 25.5 feet of drop in section 28, township 16, range 19.

South Branch.—This canal takes off from the main canal in the SW. ¼ of section 15, township 13, range 20, and carries the supply for 19,910 acres in the area to the south of the main canal of the Canada Land and Irrigation Company. It has been designed for a capacity of 222 second-feet at the division gates. Between the division gates and the controlling summit in section 32, township 12, range 19, 81 feet of drops have been provided to take up the fall in this section of the canal. In section 1, township 12, range 19, and also in section 8, township 11, range 17, flumes have been provided to carry the canal over depressions.

Extension of Canada Land and Irrigation Company System.—Two points of diversion from this system are proposed, one for the north branch from the Little Bow reservoir in section 33, township 14, range 20, and the other for the south branch from the main canal in section 8, township 14, range 19. North Branch—This canal carries the supply for all irrigable lands to the north of the main canal of the Canada Land and Irrigation Company consisting of 36,272 acres and has been designed for a capacity of 415 second-feet at the headgate. From a point on the SW. ¼ of section 2, township 17, range 19, to the end of the canal, the location is the same as for the main canal as projected under the first alternative. With the exception of a railway-crossing in section 18, township 15, range 19, no special structures are required. South Branch—This canal carries the supply for all irrigable lands to the south of the main canal of the Canada Land and Irrigation Company consisting of 19,242 acres, and has been designed for a capacity of 226 second-feet at the headgate. From a point in section 32, township 12, range 19, to the end of the canal the location is the same as for the south branch as projected under the first alternative and with the exception of the two flumes mentioned no special structures are required.

Cost Estimates.—All canals of 25 second-feet capacity and greater were profiled and excavation quantities estimated from centre-line cuts. In taking out these quantities the transverse slopes were taken into consideration. The maximum quantities were estimated, no allowance being made for overhaul. For canals of less than 25 second-feet capacity, the excavation quantities were estimated for the balanced sections, and to these 33⅓ per cent was added to allow for ground irregularities. An estimate for fencing all canals of 25 second-feet and over has been included, and a telephone system has been estimated for the entire lengths of main canals. The cost for highway bridges on all canals of greater bed-width than 10 feet has been prepared in accordance with the Provincial Government standard designs and is included in the estimates.

The following unit prices were used in estimating:

Item	Unit Cost	Remarks
Right-of-way (canal)	$25 per acre	Average figure
" (nat. channel)	$10 " "	" "
Excavation	24c. per cu yd	
Concrete (reinforced)	$30 " "	Exc., back-fill, forms, haul, steel, etc.
Concrete (plain)	$20 " "	" " "
Timber (in place)	$80 per M	
Riprap	$2 per sq. yd	
Telephone	$275 per mile	
Fencing	$350 " "	
12-inch steel pipe	$1.80 per linear foot	
18-inch " "	$2.75 " "	
24-inch " "	$3.45 " "	
30-inch " "	$4.40 " "	
36-inch " "	$6.65 " "	
48-inch " "	$12.60 " "	

The prices shown for concrete and timber are an average of actual constructional costs for the Lethbridge Northern and United districts. Summarized estimate of cost for the development of the two alternative schemes above outlined form part of this report.

Discussion of Estimates.—The estimated costs of the alternatives shown in the following tables are only the constructional costs to extend the canals of the Lethbridge Northern and Canada Land and Irrigation Company's systems. They do not include the cost of enlarging these systems to provide

for the lands of the proposed Retlaw-Lomond district. Considering the water supply available at the points of diversion shown from these two systems the estimated costs are for the canals necessary to distribute the supply to the lands of the proposed Retlaw-Lomond district. Before any such extension could be made it would be necessary for the proposed Retlaw-Lomond district to enter into an agreement with either of the above districts for the carriage of the necessary water supply so that the feasibility depends largely upon the terms of such an agreement.

Approximate cost estimates were made last year for the enlargement of the canal system of the Canada Land and Irrigation Company and the Lethbridge Northern Irrigation district. These estimates were made for the purpose of determining the comparative costs of supplying the proposed Retlaw-Lomond district with water. In preparing these estimates the area considered irrigable in each case was 100,000 acres. On this basis the cost of making the necessary enlargements to each of the projects was as follows:—

Enlargement of Canada Land and Irrigation Co. $2,269,348
Enlargement of Lethbridge Northern Irrigation district $2,370,829

It would be necessary to revise these estimates for the areas which can be actually irrigated from each of these systems in order to arrive at a fair comparison, but it is obvious in view of the much higher per acre costs necessary to extend the canals of the Lethbridge Northern district that the most economical scheme for the development of the proposed Retlaw-Lomond district is through the Canada Land and Irrigation Company's system.

There is an area of 8,670 acres which is irrigable from an extension of the Lethbridge Northern canals but cannot be reached from the Canada Land and Irrigation Company's system. This area is largely in the Sundial district and includes some of the best lands in the project. The following is an estimate of the cost to extend the canals of the Lethbridge Northern system to irrigate 25,199 acres. This is the total irrigable area to the south of the main canal of the Canada Land and Irrigation Company which can be reached from an extension of the Lethbridge Northern system.

Main Canal—		
Excavation, 351,300 cu. yds. at 24c	$ 84,312	
Right-of-way, 137 acres at $25	3,425	
Telephone, 13·7 miles at $275	3,768	
Fencing, 13·7 miles at $350	4,795	
Bridges—13 at $575	7,475	
2 at $256	512	
4 at $173	692	
1 at $64	64	
Natural channel, sec. 31-11-21 to sec. 36-11-21	39,395	
Little Bow Syphon	139,970	
Total cost main canal		$ 284,408
South Branch		303,557
Laterals		27,034
Drainage		6,970
		$ 621,969
Engineering and contingencies, 15 p.c.		93,295
Total cost		$ 715,264

Cost per acre (25,199 acres) = $28.40.

Much of the land for which these two projects (the Lethbridge Northern district and the Canada Land and Irrigation Company) have been constructed is still vacant and it will probably be many years before these two systems will be required to be operated at full capacity. In the meantime a satisfactory solution may be for either one of these systems to deliver the necessary water for lands in the proposed Retlaw-Lomond district in lieu of an equal area of vacant land for which the systems have been constructed. General plans accompany this report.

PLATE 14

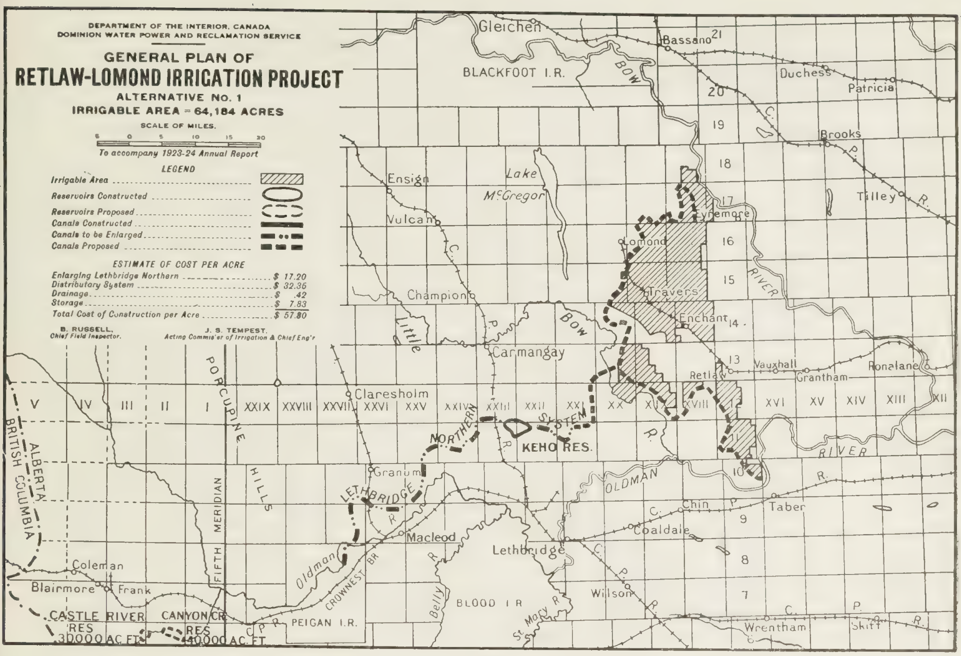


PLATE 15

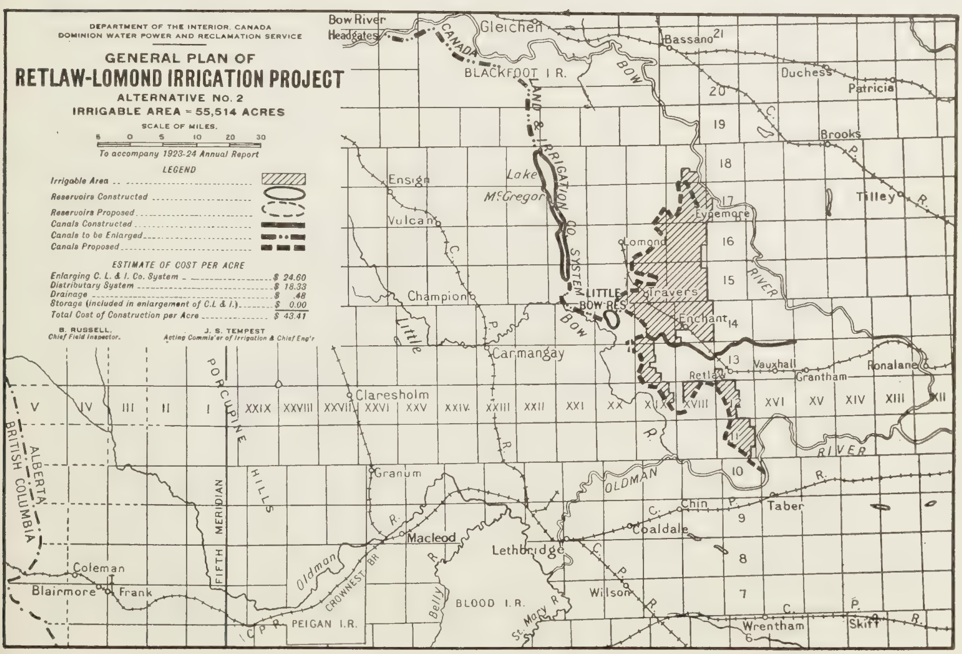


PLATE 16

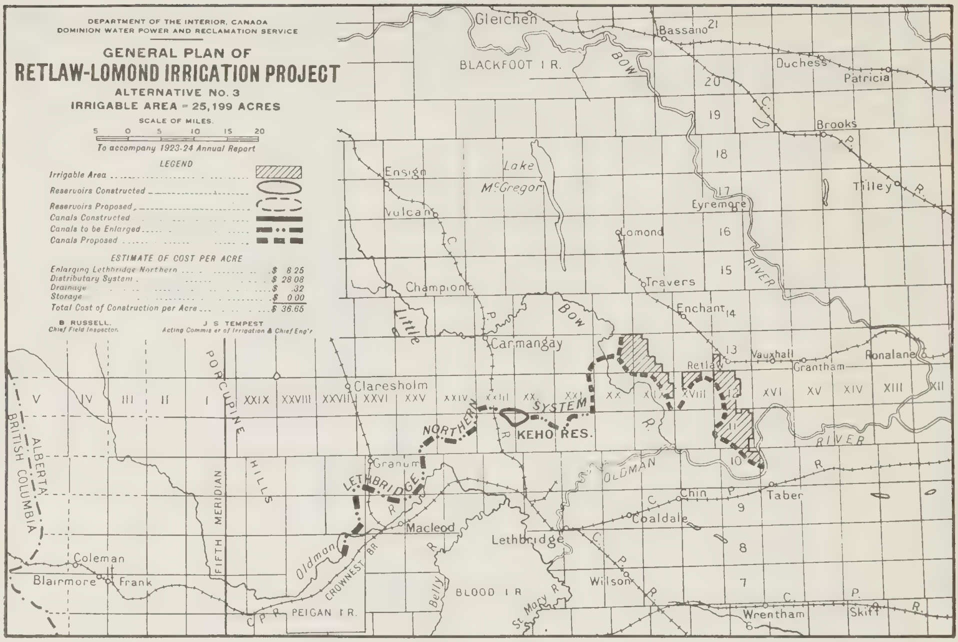
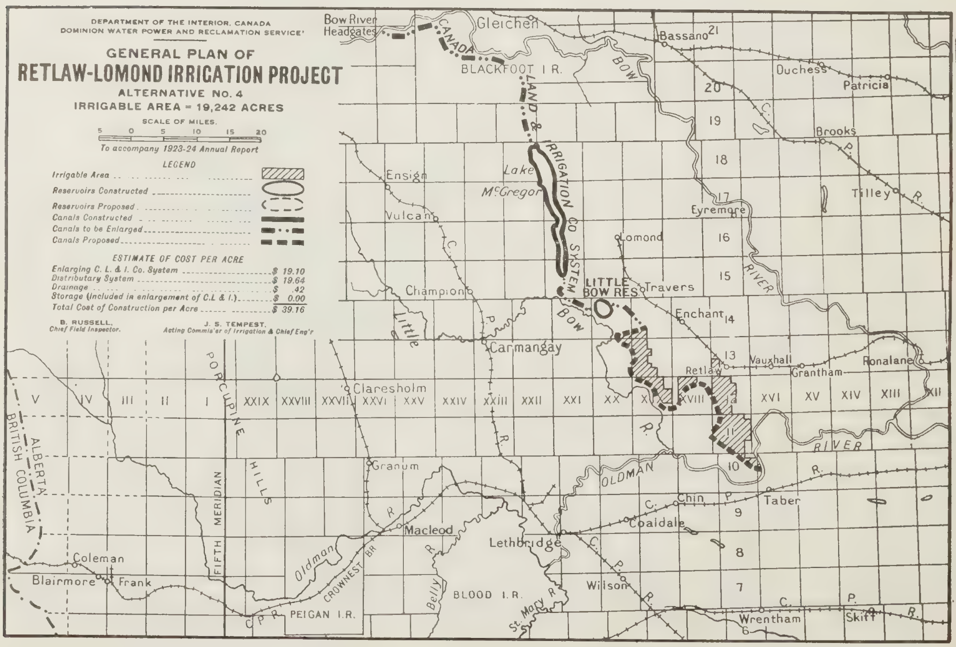


PLATE 17



Retlaw-Lomond Irrigation Project—Alternative Scheme Number 1—(Lethbridge Northern Extension)

ESTIMATED CONSTRUCTION COSTS OF MAIN CANAL AND DISTRIBUTARY SYSTEM

NOTE.—The point of diversion from the Lethbridge Northern System is at Sta. 154·00, Albion Ridge Branch.

No.	Item	Estimated Cost plus 15 p.c. to cover Engineering and Contingencies
		$ cts.
1	Outlet gate to Albion Ridge Branch, L.N.I. project	1,378 00
2	Natural channel improvements, Sta. 154·00, Albion Ridge Branch to N.E. 36-11-21 W. 4	152,937 00
3	Main Canal from N.E. 36-11-21-4 to "B" lateral turnout	1,160,269 45
4	A and B Lateral System	8,163 85
5	C " "	9,398 85
6	D " "	387 85
7	E " "	4,404 00
8	F and G " "	85,421 85
9	H " "	926 95
10	I " "	318 25
11	J " "	332 00
12	K " "	26,229 70
13	L " "	6,799 25
14	M " "	347 05
15	N " "	3,269 45
16	O " "	366 10
17	P " "	88,593 30
18	Q " "	431 15
19	R " "	3,458 55
20	S " "	142,983 20
21	T " "	461 95
22	U " "	822 00
23	V " "	24,032 65
24	W " "	5,772 00
25	South Branch Distributary System	349,090 65
26	"A" Drainage	8,015 50
27	"B" Drainage	18,843 90
	Total	2,103,454 45

Total irrigable area = 64,184·3 acres. Cost per acre = $32.77

Retlaw-Lomond Irrigation Project—Alernative Scheme Number 2—Diversion from the Canada Land and Irrigation Co's. System

ESTIMATED CONSTRUCTION COSTS OF MAIN CANAL AND DISTRIBUTARY SYSTEM

MAIN CANAL—SOUTH BRANCH POINT OF DIVERSION—N.E. SEC. 8—TP. 14—RGE. 19—W. 4th MER

No.	Item	Estimated Construction Costs plus 15% for Engineering and Contingencies	Total Irrigable Area	Cost per Acre
		$ cts.	Acres	$ cts.
1	Main Canal—South Branch and "A" Drainage	385,945 65	19,242·0	20 06

MAIN CANAL—NORTH BRANCH — POINT OF DIVERSION—LITTLE BOW RESERVOIR

1	A. and B. Lateral Systems	8,163 85	....	....
2	C. " "	9,398 85	....	....
3	D. " "	387 85	....	....
4	E. " "	4,404 00	....	....
5	F. and G. " "	85,421 85	....	....
6	H. " "	926 95	....	....
7	I. " "	318 25	....	....
8	K. " "	10,393 25	....	....
9	L. " "	2,096 25	....	....
10	N. " "	2,549 65	....	....
11	P. " "	49,960 95	....	....
12	R. " "	2,617 80	....	....
13	S. " "	133,861 05	....	....
14	Main Canal North Branch—Alternative Scheme No. 2	329,138 70	....	....
15	"B" Drainage	18,843 90	....	....
	Total	658,483 15	36,271·7	18 15

COMBINED NORTH AND SOUTH BRANCHES

	South Branch—Complete	385,945 65	19,242·0	....
	North Branch—Complete	658,483 15	36,271·7	....
	Total	1,044,428 80	55,513·7	18 81

PROPOSED CHAMPION IRRIGATION DISTRICT

It is proposed to form into a district certain lands in townships 14, 15 and 16, ranges 22, 23, 24, 25 and 26, in the Highwood River Irrigation project. A full description of this project was published in the annual report for the year 1922-23, but no progress has been made during the past year. The estimated constructional cost of the Highwood River project published in the annual report for the year 1922-23 is $1,800,823 of which approximately $420,000 is required to cover the cost of canals and reservoirs to the west of the High River flume crossing in the SW. ¼ of section 17, township 18, range 28, west of the 4th meridian, but the possibility of reducing the cost by diverting from the river at the above flume was pointed out. A study is now being made of this alternative and cost estimates will be prepared. It is hoped to considerably reduce the constructional cost of this scheme by such a division.

NORTH SASKATCHEWAN PROJECT

This project was fully reported in the annual report for the year 1922-23. The possibility of irrigating certain lands along the Rosebud river, Threehills, Kneehills and Ghostpine creeks was pointed out. During the past year a reconnaissance was made of this area for the purpose of determining approximately the extent of these irrigable areas. A fairly large tract between the Rosebud river and Kneehills creek below an elevation of approximately 3,100 feet in ranges 22, 23, 24, 25 and 26, can be reached from the proposed high-line canal from the Red Deer river. It is roughly estimated that there would be about 130,000 acres of land in this tract which would be benefited by irrigation. The soil is light, varying from sandy to clay loam. The tract appears to be well settled and is served by the Canadian National railways. Two other smaller tracts along Threehills and Ghostpine creeks consist of lands below an elevation of approximately 2,950 feet. The character of these lands is too varied to make even an approximate estimate of the irrigable contents, but it would appear that there would be at least 35,000 acres in each. This makes a total irrigable area of 200,000 acres which might be irrigated from the proposed high-line canal from the Red Deer river.

SURVEYS

Frenchman River Valley.—Article VI of the Waterways Treaty between the United States and Canada provides for an equitable division of the combined flow of the Milk and St. Mary rivers and their tributaries in the state of Montana and the provinces of Alberta and Saskatchewan for the purposes of irrigation and water-power, but in making such equal apportionment the article provides that more than half may be taken from one stream and less than half from the other.

In order to determine the area in Canada which may be irrigated from the Frenchman river (one of the tributaries affected) a plane-table survey was made of the valley from which lands have been field-classified as irrigable or non-irrigable, depending upon the possibility of serving them either by gravity or pumping schemes.

A 10-man plane-table party was employed on this survey. Field work was commenced on May 7 and completed November 22. The following is a summary of the work completed during the season:—

Number of acres plane-tabled	75,045
Number of miles of levels run	300
Number of standard bench-marks established	12
Number of soil samples tested	80
Number of river cross-sections made	53

The elevation of water surface was obtained at the top and bottom of all rapids in addition to the water-level at intermediate points along the river.

The total length of the Frenchman river from Cypress lake to the International Boundary is approximately 280 miles and the total fall in this distance 776 feet. In making the field classification all lands under projected gravity and pumping schemes were classified as irrigable provided the soil conditions were found to be suitable. The feasibility of these schemes, however, depends not only upon the quantity of water available from the Frenchman river, which involves a study of the storage possibilities, but also upon the cost of development and operation of these schemes, and, while it would appear quite feasible to irrigate these lands for which a gravity supply is possible, the question of pumping requires careful consideration.

A study has been made of pumping plants and designs and cost estimates prepared to show both the capital cost and annual cost of operation of plants for irrigation projects of from 50 to 500 acres under total heads of from 5 to 50 feet.

Estimates are now being prepared to show the capital cost, and annual cost of operation of all schemes both pumping and gravity in the valley and a schedule will be completed showing all lands which it is considered economical to irrigate.

Reservoir Reconnaissance:—For the purpose of locating any suitable sites where water might be economically stored on the Clearwater and North Saskatchewan rivers a 4-man party was organized. This party commenced field work on May 12 and disbanded on October 31. During this period the total distance covered by saddle horse and pack train was 1,285 miles. Nineteen possible sites were investigated, and sufficient data obtained from which to prepare preliminary plans and cost estimates.

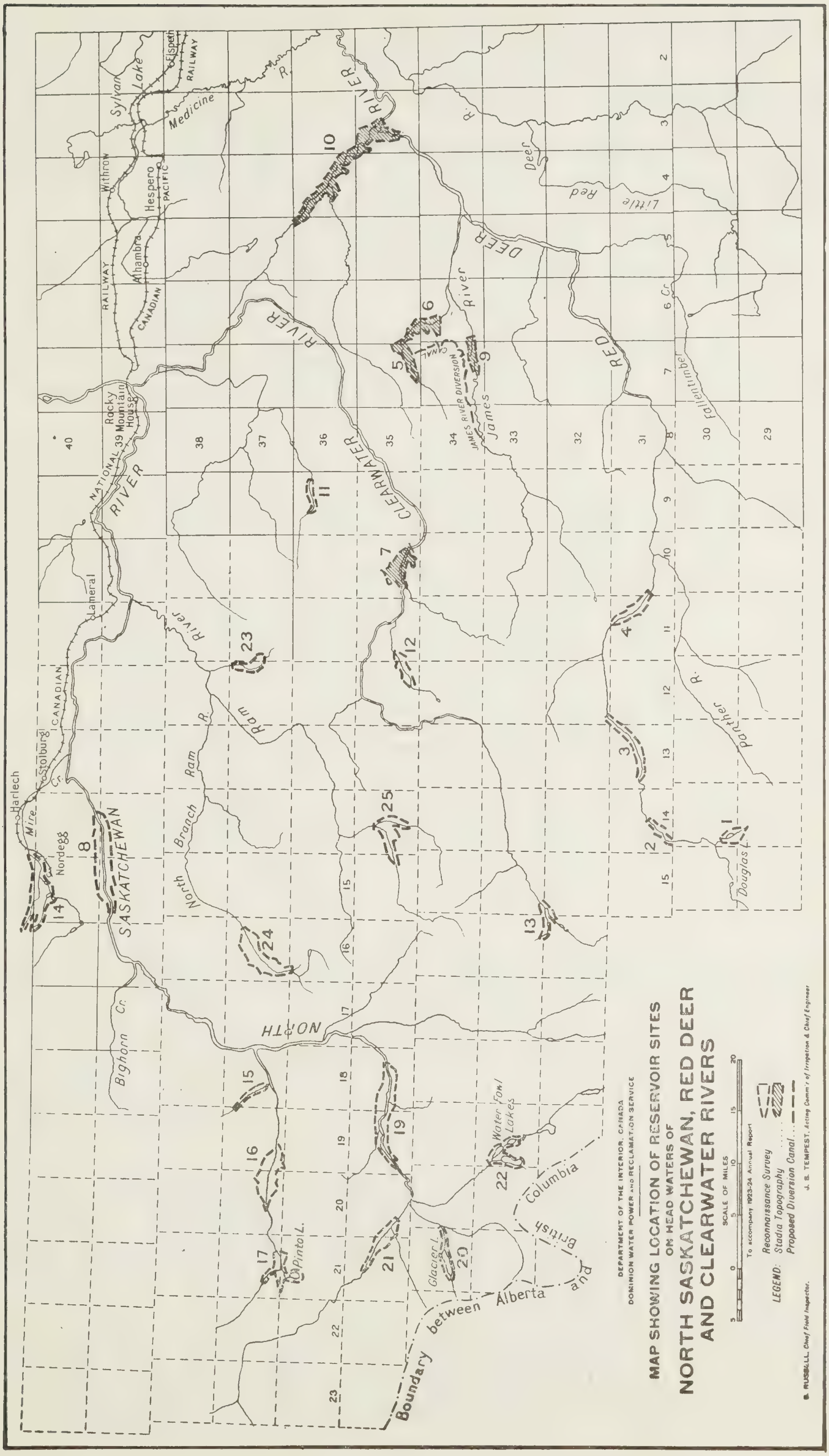
The accompanying map (Plate 18), and table, show the location and estimated cost of most of the reservoirs.

Table of Reservoir Sites Surveyed. *See plate 18 opposite.*

No.	Name	Approx. Location of Dam Sites W. of 5th Mer.	Survey: Date	Survey: Class	Survey: Engineer in Charge	Reservoir Details: Height of Dam	Reservoir Details: Flooded Area in Acres	Reservoir Details: Capacity in Ac. Ft.	Reservoir Details: Estim-Cost	Reservoir Details: Cost per Ac. Ft.
						′			$	$ cts.
1	Douglas Lake	Sec. 7, Tp. 30, Rg. 14	Oct. 1922	Reconnaissance	A. B. Cook	110	1,458	64,500	756,513	11 73
2	Red Deer River No. 1	Sec. 16, Tp. 31, Rg. 14	Oct. 1922	"	"	110	545	21,000	493,264	22 44
3	Red Deer No. 2	Sec. 6, Tp. 32, Rg. 12	Nov. 1922	"	"	195	2,192	142,500	1,977,841	13 88
4	Red Deer River No. 4	Sec. 18, Tp. 31, Rg. 10	Nov. 1922	"	"	134	1,490	67,000	805,430	12 02
5	Burntstick Lake	Sec. 7, Tp. 35, Rg. 6	Aug. 1922	"	"	....	....	....	....	....
	Burntstick Lake	Sec. 7, Tp. 35, Rg. 6	Sept. and Oct. 1922	Stadia. Top	J. C. Ells	39	1,804	40,360	197,893	4 90
6	Stony Creek	Sec. 29, Tp. 34, Rg. 6	Aug. 1922	Reconnaissance	A. B. Cook	....	....	....	....	....
	Stony Creek	" "	May and July 1923	Stadia. Top	M. H. Marshall	61	2,600	39,870	187.787	4 71
7	The Gap Clearwater	Sec. 2, Tp. 35, Rg. 10	June 1923	Reconnaissance	N.M.Sutherland	....	....	....	....	....
	The Gap Clearwater	" "	Oct. 1923	Stadia Top	M. H. Marshall	148	3,800	157,202	2,482,615	15 79
8	The Gap, North Saskatchewan	Sec. 3, Tp. 40, Rg. 14	Aug. 1923	Reconnaissance	H. J. Cooper	170	4,575	368,000	2,318,800	6 30
9	James River	Sec. 7, Tp. 34, Rg. 6	Aug. 1922	"	A. B. Cook	....	....	....	....	....
	James River	" "	Nov. 1922	Stadia Top	J. E. Ells	108	1,226	48,652	1,343,655	27 60
10	Raven—Red Deer	Sec. 22, Tp. 35, Rg. 3	May 1923	Reconnaissance	I. R. Strome	....	....	....	....	....
	Raven—Red Deer	" "	Aug. and Sept. 1923	Stadia Top	M. H. Marshall	78	8,000	152,000	5,603,100	36 86
11	Swan Lake	Sec. 25, Tp. 36, Rg. 9	June 1923	Reconnaissance	N.M.Sutherland	35	950	19,300	27,840	1 44
12	Clearwater Cutoff	Sec. 18, Tp. 35, Rg. 11	July 1923	"	"	165	2,200	99,350	1,536,277	15 46
13	Lower Clearwater Lake	Sec. 5, Tp. 33, Rg. 15	July 1923	"	"	124	900	36,400	605,679	16 64
14	Shunda Creek	Sec. 6, Tp. 41, Rg. 14	Sept. 1923	"	H. J. Cooper	70	4,140	100,000	183,672	* 1 85
15	Coral Creek	Sec. 9, Tp. 37, Rg. 18	Sept. 1923	"	"	60	846	15,700	39,000	* 2 50
16	White Goat River	Sec. 4, Tp. 37, Rg. 19	Aug. 1923	"	"	60	4,760	136,000	89,060	* 0 65
17	Cataract Creek	Sec. 5, Tp. 37, Rg. 20	Aug. 1923	"	"	100	1,810	64,600	1,227,400	*19 00
18	North Saskatchewan Siffleur	....	....	....	"	Not	Feasible			
19	Whirlpool, North Saskatchewan	Sec. 14, Tp. 35, Rg. 18	Aug. 1923	"	"	140	6,820	368,300	1,345,200	3 65
20	Glacier Lake	Sec. 19, Tp. 34, Rg. 20	Sept. 1923	"	"	70	1,410	75,000	117,960	* 1 60
21	North Fork, North Saskatchewan	Sec. 8, Tp. 35, Rg. 20	Sept. 1923	"	"	100	2,871	126,000	1,083,600	* 8 60
22	Mistaya River	Sec. 29, Tp. 33, Rg. 19	Aug. 1923	"	"	100	2,440	137,000	596,500	* 4 35
23	Falls Creek	Sec. 25, Tp. 37, Rg. 12	Oct. 1923	"	"	50	295	9,430	30,176	* 3 20
24	North Fork Ram River	Sec. 14, Tp. 37, Rg. 6	Oct. 1923	"	"	100	3,050	174,000	588,000	* 3 40
25	South Fork Ram River	Sec. 28, Tp. 35, Rg. 14	Oct. 1923	"	"	50	3,364	91,100	300,630	* 3 30

NOTE:—Cost of Conduits not included on Reservoirs marked *.
Estimated cost of James River diversion canal $338,848, to be added to costs shown for Reservoirs No. 5 and 6 to obtain unit cost of storage.

PLATE 18


DEPARTMENT OF THE INTERIOR, CANADA
DOMINION WATER POWER AND RECLAMATION SERVICE
MAP SHOWING LOCATION OF RESERVOIR SITES
ON HEAD WATERS OF
NORTH SASKATCHEWAN, RED DEER
AND CLEARWATER RIVERS
SCALE OF MILES
To accompany 1923-24 Annual Report
LEGEND: Reconnaissance Survey
Stadia Topography
Proposed Diversion Canal
B. RUSSELL, Chief Field Inspector.
J. B. TEMPEST, Acting Comm'r of Irrigation & Chief Engineer
Sylvan Lake
Elspeth
Medicine R.
Withrow
Hespero
Alhambra
CANADIAN PACIFIC RAILWAY
CANADIAN NATIONAL RAILWAY
Rocky Mountain House
RED DEER RIVER
Little Red Deer R.
James River
JAMES RIVER DIVERSION CANAL
CLEARWATER RIVER
Fallentimber Cr.
Panther R.
Douglas
NORTH SASKATCHEWAN RIVER
Lameral
Stolburg
Harlech
Mire Cr.
Nordegg
North Branch Ram R.
Ram R.
Rivers
Bighorn Cr.
Pinto L.
Glacier L.
Water Fowl Lakes
Boundary between Alberta and British Columbia

Reservoir Detail.—For the purpose of making detailed surveys of those reservoir sites which appeared from reconnaissance to require further investigation a 9-man party was organized, the transport equipment consisting of pack train and democrat.

This party commenced field work on May 7 and completed on November 7. During this period topographical surveys were made of over 14,697 acres mostly covered with light timber and brush, and 28·2 miles of traverse were run for supply canals. The following sites were surveyed:—

Stony Creek site—tps. 34 and 35, rge. 6, W. 5th M.

Red Deer and Raven Rivers site—tps. 34 and 35, rges. 3, 4, 5, W. 5th M.

Clearwater River site—tp. 35, rge. 10, W. 5th M.

Stony Creek Site.—In addition to the proposed Burnstick Lake site surveyed in 1922-23, it is proposed to create additional capacity on Stony creek, in which to store water diverted from the James river, by constructing a dam across Stony creek valley about 3½ miles below Burnstick lake. A survey was completed of this site.

Since the annual run-off from Stony creek is not in itself sufficient to fill these reservoirs a canal was located connecting each with the James river, through which it is proposed to divert water from the James river during the open-water period each year. The canal headworks consist of a gravity type concrete weir with headgates. The length of canal is 24 miles, and has been designed for a capacity of 500 second-feet.

The dam for the Stony creek site has been designed to consist of an earth fill with a crest length of 2,150 feet and maximum height of 61 feet. A spillway for 1,000 second-feet, and outlet gates of reinforced concrete construction to pass 1,200 second-feet have been provided. Three small subsidiary dams have been designed to maintain the full supply level.

Plans and cost estimates have been compiled for all structures.

The estimated cost of the combined development is as follows:—

Diversion weir headworks—	
Main supply canal and outlet structures	$ 294,650 20
Burnstick lake reservoir including dam, spillway and outlet gates	144,167 90
Stony creek dam, spillway and outlets	163,292 98
	$ 602,111 08
Engineering and contingencies 15%	90,316 66
Total	$ 692,427 74

No provisions have been made in the above estimate for land damages as none of the flooded area has been alienated.

The total storage provided is as follows:—

Burnstick Lake site	40,360 ac.-ft.
Stony Creek site	39,870 "
Total	80,230 ac.-ft.

Estimated cost per acre-foot storage $8.63.

Red Deer-Raven River Site.—By means of a dam on the Red Deer river in section 22, township 35, range 3, west of the 5th meridian, it is possible to create a large reservoir in the valleys of the Red Deer and Raven rivers in townships 35 and 36, ranges 3, 4 and 5, west of the 5th meridian. A survey was made of this site during the past season and plans and cost estimates have since been prepared.

The dam for this site has been designed to consist of a hollow concrete weir 1,500 feet in length with a maximum height of 75 feet. The weir is flanked at both ends by earth-fills making the total crest length of the structure 3,720 feet. Headgates have been designed to discharge 2,275 second-feet or,

the estimated capacity of the main canal of the North Saskatchewan project, under a head of 5 feet.

This dam would cause back-watering for a distance of 13 miles with an average width of approximately three-quarters of a mile flooding 7,334 acres of fairly good agricultural land mostly in the valley of the Raven river. The estimated capacity is 152,000 acre-feet.

In connection with the North Saskatchewan project whether storage is created on the Red Deer river or not, a diversion weir is required on the river to elevate the water into the proposed diversion canal. In estimating the cost of the proposed storage a weir of just sufficient height to turn water into the proposed canal was first estimated and this cost deducted from the total cost of the higher dam in order to arrive at an estimated cost of storage created by building the higher dam.

The following is the estimated cost of the development:—

Cost of storage, dam, headworks, land damages, etc.	$ 6,462,515 84
Cost of diversion weir, headgates, land damages, etc.	859,415 31
Cost of storage	$ 5,603,100 53
Cost of storage per acre-foot	$ 36 86

Clearwater River Site.—The location of this site is at the "Gap" on the Clearwater river in section 2, township 35, range 10, west of the 5th meridian. The survey was made during the past season and plans and cost estimates have since been completed.

It is proposed to construct a rock-fill dam with a maximum height of 148 and crest length of 2,135 feet. The design provides for a spillway 600 feet in length capable of passing a flood of 30,000 second-feet. The outlet structure consists of three 4-foot diameter pipes through the dam at river level operated by gates. The structure has been designed for a capacity of 1,245 second-feet.

The construction of this dam would create storage capacity of 157,202 acre-feet, and would cause back-watering for a distance of $4\frac{1}{4}$ miles at a maximum width of approximately $1\frac{3}{4}$ miles. The area which would be flooded consists largely of meadow flats and burned timber lands and the resultant damage would be negligible. The site is wholly in the forest reserve so that no charge has been made in the estimates for damage to lands.

The estimated capacity of this site is 157,202 acre-feet. The estimated cost is $2,482,614.70 or at the rate of $15.79 per acre-foot.

ALKALI TEST PLOTS AT MAPLE CREEK, SASKATCHEWAN

The location and arrangement of the plots, the purpose of the investigation, method of conducting the farm operations, irrigation, alkali tests, the collection of meteorological data, etc., have been fully explained in detail in the annual report for 1922. All work was conducted in a manner similar to that of 1922, as it is the intention to make no material changes in operation throughout the period of the test.

The following table gives the dates of irrigations, the precipitation and the yields per acre:—

Plot	Area Acres	Irrigation — Date and Depth in ac.-ft.			Duty of Water	Rain-fall	Total Depth Rec'd.	Depth Used to Grow Crop	Yield per Acre
		Apr. 14	June 2	July 2					
A	0·029	0·50	0·33	0·33	1·16	0·94	2·10	2·24	0·66 T.
F	0·029	0·50	0·33	0·33	1·16	0·94	2·10	2·14	0·55 T.
B	0·029	0·50	0·33	0·33	1·16	0·94	2·10	2·29	1·27 T.
E	0·029	0·50	0·33	0·33	1·16	0·94	2·10	2·10	0·82 T.
C	0·026	0·50	0·33	0·33	1·16	0·94	2·10	2·22	20·1 Bus.
D	0·026	0·50	0·33	0·33	1·16	0·94	2·10	2·17	26·6 Bus.

NOTE.—Yield of straw upon plot C=1·33 tons per acre.
" " D=1·69 " "

Evaporation, Precipitation and Temperature Records at Maple Creek, Sackatchewan, for 1923

Month	Evaporation inches	Precipitation inches	Mean Temperature for month
April	4·4	0·39	41·0
May	6·3	1·00	53·6
June	5·5	4·46	61·5
July	5·5	4·53	66·5
Aug.	5·4	0·64	61·2
Sept.	4·8	0·08	54·4
Oct.	2·1	0·24	44·3
Total April-Sept.	31·9	11·10	
Average April-Sept.			56·4

NOTE:—Only averages and totals for period April to Sept. used so that records can be compared with other published records.
Date of last frost May 18, temperature 27° F.
Date of first frost Sept. 12, temperature 30°F.
Number of days between frosts=117.

The first visit for the season of 1923 to the plots was made on April 14, and the following observations were made:—

Plots "A" and "F".—The soil was somewhat checked, the cracks being about ⅛ inch wide. The grass was just turning green at the base of the plants. The dykes around plot "A" were in places almost white with alkali, while those around Plot "F" had some alkali at the base. There was no evidence of alkali upon the soil.

Plots "B" and "E".—The surface soil was soft and mellow. There were no traces of alkali upon the soil, but some could be detected in spots upon the base of the dykes.

Plots "C" and "D".—The soil was very mellow and there was no alkali showing except a little upon the base of the dykes.

At the time of this visit soil samples were taken of each plot in the usual manner. After these samples were taken a 6-inch irrigation was applied to all the plots. A second visit was made to the plots April 28. The plots were harrowed before seeding and also received a light harrowing afterwards. Marquis wheat from the station at Brooks, Alberta, was seeded with a single disc drill at the rate of 1¼ bushels per acre. Since the grass upon the plots "E" and "F" was coming up in bunches with bare spaces between, averaging about one square foot in area, the soil was stirred up with a rake and seeded with rye grass broadcasted 6 pounds to the acre. The second irrigation was applied June 2. The following observations were noted:—

Plots "A" and "F".—The grass averaged about 6 inches in height, it was beginning to thicken and to spread over the bare spots. The soil in its natural state is only partly covered with grass and here and there a bush of grease wood and sage. If it is irrigated each season the native grasses, such as blue joint, gradually spread until the soil is covered with a heavy growth which in time becomes sod bound and requires to be broken up.

The soil is somewhat cracked. These cracks were in places three-quarters of an inch wide and 6 inches deep.

Plots "B" and "E".—The grass averaged 10 inches in height and was very green with a vigorous growth. That along the foot of the dykes was about 15 inches in height. The grass seed that was sown April 28 was not yet showing. The surface soil was checked slightly although moist about one-half inch underneath. The cracks were one-eighth inch wide and one-half inch deep.

Plots "C" and "D".—The soil was lightly checked in figures about two inches square, though moist below at a depth of one-half inch. The surface was baked about one-quarter inch in depth, but it crumbled easily between the fingers. The wheat was backward and patchy. Part of it was just coming through the ground, while some was about 4 inches in height. It is probable that the thin crust upon the surface had a retarding effect upon the growth. The plots received at this time a 4-inch irrigation. The month of June was very wet so that the last irrigation was deferred until July 2, when another depth of 4 inches was applied.

The observations for each plot on July 2 were as follows:—

Plots "A" and "F".—The grass averaged slightly over a foot in height with foxtail appearing to predominate. The soil was badly cracked. The old trail crossing the plots was still quite bare.

Plots "B" and "E".—The bromus and rye grass averaged about 30 inches in height with the bromus predominating. The growth also appeared heavier in plot " B " than in plot " E" due to the larger bare places in the latter. The soil was slightly checked.

Plots "C" and "D".—The grain was uneven and averaged about 18 inches in height. The unevenness in the stand may be partly due to the same causes which produced bare places in the original virgin conditions of the soil. The stand, however, was much superior to that of the previous year.

On July 30 the grass plots "B" and "E" were cut. The grass averaged about 36 inches in height, with the bromus predominating. The yield was heavier in plot "B" than in plot "E." The western rye seed planted April 28 in these two plots was not yet in evidence. Probably it will be dormant until next spring and then germinate. The vigorous growth of the brome grass bears out the result of observation in this district that it appears to be a very hardy grass, and seems to thrive where the conditions are at all favourable.

The wheat was cut and stooked August 20. It stood about 3 feet 8 inches in height. The stand was generally light, although in places excellent; the yields are given in the above table. The space between plots "C" and "D" and the west end of the lots was seeded in 1922 to sweet clover. It was given no attention nor any water until this season when two irrigations were applied.

A very good catch was obtained and the sweet clover along the edge of plots "C" and "D" became quite vigorous as a result of sub-surface irrigation from these two plots. The clover was cut before it had a chance to go to seed. The conclusion to be derived from this experiment is its vigorous growth in this soil. One plant was dug out by the roots, and the main stem was over one inch in diameter and penetrated the ground to a depth of 20 inches. Obviously this makes an excellent plant to use in building up this soil to a higher state of fertility.

The following observations were noted for this season's crop:—

1.—The soil bakes readily after irrigating. Cracks soon open up in the soil increasing the surface area exposed to the dry air with an increased loss in soil moisture.

2.—The surface baking and cracking is extremely bad upon the uncultivated natural grass plots, less upon the plots seeded to grass and least upon the cultivated plots seeded to wheat.

3.—Ploughing and seeding to cultivated grasses produces a heavier yield than leaving land in its virgin state and depending upon native grasses.

4.—Surface cultivation conserves moisture and therefore increases plant growth.

5.—The idea early entertained by engineers in charge of the work in the Maple Creek district, that such heavy soils could probably not absorb more than an annual 12-inch application of water is not substantiated by results

thus far obtained. Fourteen inches is now being applied to the plots and this amount appears inadequate for a soil so lacking in humus and soil fertility, and subject to surface cracking and baking with a resultant high loss in evaporation.

6.—A deep rooted plant which draws its nourishment and moisture from the lower depths seems more vigorous upon such heavy soils subject to surface cracking and baking than shallow rooted plants.

Conclusion.—It would be rather premature at this time to attempt to draw definite conclusions regarding the productivity of such soils under irrigation. The results thus far are encouraging, when the deficiency in humus in the soil is taken into consideration. It would appear at this time advisable to attempt to improve the fertility and texture of the soil in plots "C" and "D" and probably "B" and "E" by growing sweet clover or alfalfa if it will thrive in this soil.

Report on Duty of Water Investigations for 1923

BROOKS IRRIGATION EXPERIMENT STATION

Climatology.—Climatic conditions at Brooks during 1923, April to September inclusive, are characterized chiefly by added precipitation received during the month of June. Favourable distribution made this precipitation particularly effective. With the exception of certain seed crops, however, the total amount received was inadequate for economic crop production and where not supplemented by sufficient irrigation, yields obtained were very low. The season, owing chiefly to the amount and distribution of rainfall, was unfavourable for alfalfa seed production.

Mean temperatures for the most part varied little from average for the past eight years. The frost-free period for the season was 105 days and the period from the last spring to the first fall killing frost was 127 days. The early frost in September ruined much late alfalfa seed.

April.—Low temperatures and several snow flurries prevented work on the land during the first half of the month. The mean maximum temperature was 60.1°, the mean minimum 26.6° and average mean was 43.4°. The average mean temperature for April during the past eight years was 42.1°. Field operations commenced at the station on the 14th and the first seeding was done on the 23rd. The total precipitation for the month was 0.78 inch of which 0.52 was received on the 29th. Evaporation for the month was 3.7 inches, which is 1.04 inches above the average for the five preceding years.

May.—The average maximum temperature for May was 68.7°, the average minimum 37.9° making an average of 53.3°, 14.5° of frost which was recorded on the 17th damaged peas and other less hardy crops to some extent, otherwise conditions for plant growth were favourable. Total precipitation for the month was 0.90 inch. Total evaporation was 4.89 inches.

June.—The total rainfall recorded during June was 4.19 inches. The mean minimum temperature was 49.6°, the mean maximum 74.2° and the average was 61.9°. Total evaporation was 3.22 inches or 3.15 inches below the average for the month of June during the five preceding years. Conditions during the month were exceedingly favourable for vegetative growth. The continuous rainy weather, however, was less favourable for seed production of certain crops, particularly alfalfa.

July.—Temperatures varied little from averages of previous years, the mean maximum being 80.0°, the mean minimum 54.5° and the average mean 67.3°. Rainfall was recorded on ten days during the month, the total received being 1.87 inches.

Evaporation recorded was the lowest for July of any year during 1918-1923 inclusive, being 1.57 inches below the average for that period. The total

evaporation for the month was 5.13 inches. Humid atmospheric conditions and sultry weather were prevalent during the month. Rust occurred to a slight extent.

August.—The mean temperature of 63.2° was 1.6° below the average for August during the eight preceding years. The mean maximum was 78.2° and the mean minimum 48.2°. Rainfall was recorded on nine days during the month and the total received was 1.75 inches, which is only 0.12 inch above the average for this month for the period 1918-1922 inclusive. Total evaporation was 3.18 inches, or 2.48 inches below average. Ideal harvest weather prevailed, particularly during the latter part of the month.

September.—No rainfall was recorded during the month, excellent harvest weather continued. The average maximum temperature was 72.3°; the average minimum temperature was 37.8° and the mean was 55.0°, which is 1.5 degrees above the average. The maximum temperature recorded during the month was 91.0° and the minimum was 17.5° which occurred on the 22nd. Total evaporation was 3.12 inches.

Season's Results.—The results of the past season's work are given in the following "Plot Series Record Sheets."

In studying the tables it is to be noted that the column "Total Depth Received" indicates the sum of the depth applied by irrigation and the depth received as precipitation. The column headed "Total Depth Used in Growing the Crop" shows the depth of water actually used in growing the crop as determined by soil moisture tests.

Rotation Schedule.—The following were the rotations practised:—

"A"—Alfalfa five years, potatoes, wheat, flax.
"B"—Clover four years, corn, oats, wheat, oats.
"C"—Grass three years, potatoes, barley, wheat.
"D"—Red clover two years, oats, barley.
"E"—Peas, wheat, oats, barley.

During 1923 the water requirements of wheat determined under four different conditions of soil fertility, namely:—

1. As the second crop following three years of alfalfa.
2. As the third crop following three years of alsike clover.
3. As the first crop following peas.
4. As the third crop following two years of grass.

The water requirement of oats was determined under four conditions of fertility, barley under three, potatoes under two and flax under one.

By following this rotation schedule it is possible to have, in each year, grain crops coming immediately after grains or grasses, second year after legumes and third year after legumes, thus giving an opportunity to secure data to the effect, that as the soil fertility decreases, the amount of water required to produce a given yield per acre increases.

Wheat.—In rotation "A" the maximum yield, 57.5 bushels per acre, was produced under a total depth received of 2.28 feet.

In rotation "B" the maximum yield, 51.3 bushels per acre, was produced under a total depth received of 1.78 feet.

In rotation "E" the maximum yield 50.1 bushels per acre, was produced under a total depth received of 1.63 feet.

In rotation "C" the maximum yield, 36.3 bushels per acre, was produced under a total depth received of 1.63 feet.

Summarizing the results of the four wheat series, it is shown that the maximum yields were produced with an average total depth received of 1.87 feet, of which 0.77 foot was rainfall. In rotations "B", "E" and "C", the application of additional amounts of water produced a decrease in yield. In rotation

" A " the maximum yield coincides with the maximum depth received. The maximum yield of the four series, 57.5 bushels per acre, under a total depth received of 2.28 feet, was grown on land that had been in alfalfa 1918 to 1921 and in potatoes in 1922.

Oats—In rotation " D " the maximum yield, 135 bushels per acre was produced under a total depth received of 1.72 feet. In rotation " B " the maximum yield, 123.5 bushels per acre, was produced under a total depth received of 1.78 feet. In rotation " E " the maximum yield, 90.5 bushels per acre, was produced under a total depth received of 2.22 feet. In rotation " B[1] " the maximum yield, 124 bushels per acre, was produced under a total depth received of 2.28 feet.

Summarizing the results from the four oat series it is shown that the maximum yields were produced with an average total depth received of 2.00 feet (same as in 1922) of which 0.75 foot was rainfall.

The maximum yield of the series, 135 bushels per acre, under a depth of 1.72 feet, was grown on land that had been in clover in 1921 and 1922.

Barley.—In rotation " D " the maximum yield, 59.2 bushels per acre, was produced under a total depth received of 2.72 feet. In rotation " C " the maximum yield, 51.1 bushels per acre, was produced under a total depth received of 1.72 feet. In rotation " E " the maximum yield, 38.1 bushels per acre, was produced under a total depth received of 1.69 feet.

Summarizing the results from the three barley series it is shown that the maximum yields were produced under an average total depth received of 2.04 feet, of which 0.71 foot was rainfall.

The maximum yield of the three series, 59.2 bushels per acre, was grown on land that had been in red clover in 1920 and 1921 and had grown oats in 1922.

Flax.—In rotation " A " the maximum yield, 24.1 bushels per acre, was produced under a total depth received of 1.79 feet, of which 0.79 foot was rainfall.

Alfalfa Hay.—Rotation " A " 1920 seeding. The maximum yield 5.92 tons per acre, was produced under a total depth received of 2.29 feet, of which 0.79 was rainfall.

Nineteen twenty-one seeding; maximum yield 5.88 tons per acre was produced under a total depth received of 2.29 feet, of which 0.79 foot was rainfall.

Nineteen twenty-two seeding; the maximum yield, 4.48 tons per acre, was produced on plot 50-E under a total depth received of 2.79 feet, although on plot 50-D a yield of 4.45 tons per acre was produced under a total depth applied of 1.95 feet.

Summarizing the results from the three seedings of rotation " A " it is shown that the maximum yields were produced under an average depth received of 2.45 feet, of which 0.79 foot was rainfall.

The average maximum yield was 5.43 tons per acre. The average depth used in growing the maximum yields was 2.45 feet, or 29½ inches.

Grass Hay.—The maximum yield of grass hay, 1.72 tons per acre, was produced under a total depth received of 1.49 feet, of which 0.49 foot was rainfall.

Field Corn.—The maximum yield of field corn, 7.77 tons dry weight of stover, was produced under a total depth received of 1.29 feet of which 0.79 foot was rainfall.

Peas.—The maximum yield of peas, 34.8 bushels per acre, was produced under a total depth received of 1.78 feet, of which 0.78 foot was rainfall.

Potatoes.—In rotation " A " the maximum yield, 470.4 bushels per acre, was produced under a total depth received of 1.64 feet, of which 0.79 foot was rainfall. The non-irrigated plot produced 163.7 bushels per acre.

In rotation "C" the maximum yield, 372.1 bushels per acre, was produced under a total depth received of 1.46 feet, of which 0.79 foot was rainfall. The non-irrigated plot produced 171.9 bushels per acre.

Summarizing the results from the two potatoe series it is shown that the maximum yields were produced under an average depth received of 1.55 feet of which 0.79 foot was rainfall.

FARM DEMONSTRATION, 1923

The program of farm demonstration work adopted for 1923 provided for the maintenance of twelve plots of approximately five acres each, upon which the irrigation specialist would apply, by economical methods, the exact amount of water required to supplement the rainfall, and in other ways demonstrate the principles of irrigation practice to the farmer and his immediate neighbours.

The following table gives the yields obtained from the irrigated and non-irrigated portions of each of the plots that were irrigated. No water was available for the irrigation of plots No's. 6, 7, 8, and 9, due to a washout of the Lethbridge Northern main canal at the headworks. No water was available for plots 3 and 10 due to the fact that because of rainy weather no demands were made for water by farmers under the canals supplying these plots and consequently no water was carried in the canals.

The precipitation between seeding and harvest varied from sixteen inches at Hillspring to about nine inches at plot No. 5 near Commerce.

The increase in yield of the irrigated plots over non-irrigated portions of the same plots varied from 2.9 bushels per acre at Hillspring where the rainfall was sixteen inches to 20.5 bushels per acre at plot No. 5 where the rainfall was around nine inches.

It is interesting and encouraging to note that when the land received an adequate amount of water, applied at the right time in irrigations of uniform depth, it was able to produce from 33 to 52 bushels per acre.

Results from Farm Demonstration Plots 1923

No.	District	Owner	Location	Plot area including Laterals	Irrigation applied	Yield per acre in bushels			Remarks
						Irrigated	Non-irrigated	Increase	
				acres					
1	Taber......	W. J. Scott....	SE. 1-10-16	....	....	....	....	....	Damaged by cut-worm.
2	"	Cook Bros....	NW. 20-9-16	4·95	3x4½″=13½″	21·7 (est. 45 bu.)	19·0 (est. 25)	est. 20·0	Irrigated portion recd. 50 p.c., hail damage.
3	"	J. L. Anderson	NE. 19-9-17	5·13	....	....	22·0	....	Water not available for irrigation.
4	Lethbridge Northern..	I. Darres.....	NE. 34-10-20	5·27	3x4½″=13½″	33·1	20·2	12·9	5 p.c. hail damage.
5	" ..	G. E. Foster..	NE. 8-11-21	4·90	1x2½″ 2x4″ =10½″	45·5	25·0	20·5	5 p.c. hail damage.
6	" ..	T. Croft......	SW. 27-10-22	....	....	....	....	....	No water available.
7	" ..	G. Grier......	NW. 29-9-26	....	....	....	....	....	" "
8	" ..	Lucia.....	NE. 35-10-25	....	....	....	....	....	" "
9	" ..	R. Urch......	NW. 34-9-23	....	....	....	....	....	" "
10	United......	Hovis....	SW. 27-5-26	....	....	....	....	....	" "
11	"	B. Quinton....	NE. 1-5-27	3·80	2x4½″ 1x3″ =12″	45·1	34·7	10·4	
12	"	J. B. Merrill..	NE. 7-4-27	4·97	2x4½″=9″	51·9	49·0	2·9	

The figures in parentheses for the yield of plot No. 2 are estimates of the yield which the plot would have produced had it not been hailed.

These results but prove the findings of the Brooks Experiment Station, *i.e.*, that under each condition of soil fertility a definite amount of water is required by the grain plant to produce its maximum yield, and if this amount is not applied, both in total quantity applied, and in time and depth per irrigation in addition to the rainfall, then invariably subnormal yields will be obtained.

The frequent rains during the season served to keep the surface soil wet, and as long as the precipitation was ample for the daily needs of the plant a very vigorous and rapid growth was obtained. But the farmers, observing the wet surface of the soil, placed too much reliance on the rainfall, and did not consider the *amount* of precipitation received in connection with the normal requirements of the crop, so that when a period of drought occurred in July, those that had not irrigated found that the shallow soil moisture area of their fields was rapidly dried out to such an extent that the number of kernels of grain formed in the heads was appreciably restricted. On the other hand, where the land had been irrigated, there remained stored in the soil to a considerable depth sufficient moisture to supply the crop's needs during the July drought and other short droughts, and to enable it to go forward unrestricted in the formation of the kernels of grain.

On an average three kernels of wheat to a spikelet were obtained on the irrigated portion of the plot, and but two kernels of wheat to a spikelet on the non-irrigated portion. The farmers made note of this phenomenon, which was of much value in impressing upon them the need of a stored supply of moisture.

The value of the results obtained this season lies not so much in the yields obtained per acre, as in the instruction that farmers have received in the principles of economical irrigation practice.

Some of the farmers in the more recently constructed irrigation districts had very little knowledge of the distribution of the water by means of field laterals and did not fully appreciate the necessity of properly spacing the field laterals so that their fields would receive irrigations of uniform depths. Their conception of a ditch of adequate size fell short of the size actually required to deliver the water without endless shovel work on the part of the irrigator to prevent leaks.

Having been in close touch with the work on the demonstration plots, and having observed each operation in ditch construction and irrigating as performed by the irrigation specialist the farmers are now in a position to fully appreciate the fact that large yields are possible when an adequate amount of water is supplied to the crops. They have learned the economy and benefit of frequent light irrigations. They know from their own experience, by having large yields produced upon their own lands, under conditions with which they are fully familiar, that the irrigation methods demonstrated by the irrigation specialists are not only practical but profitable, and that by following such methods they may produce the same yields over the remaining portion of their farms that have been produced on the demonstration plots.

Throughout the season the work on each plot was followed with keen interest by the farmers' immediate neighbours who also received much benefit from this work.

Wheat (Marquis), 1923—Irrigation Experiment Station, Brooks, Alberta

ROTATION A

PLOT SERIES RECORD

Plot No.	Area Acres	Irrigation: Date and Depth Applied in Acre-feet per acre — May 30	June	June 13	June 21	June	July 5	July 11	July	July 26	Aug. 1	Duty of Water	Rainfall April First to Harvest	Total Depth Received	Total Depth used in Growing Crop	Yield per Acre	Remarks
												Ft.	Ft.	Ft.	Ft.	Bus.	Harvested
56 A.........	0·0289	......	....	....	....	....	....	....	....	....	......	......	0·72	0·72	0·68	11·95	Aug. 11
B.........	0·0297	......	....	0·33	....	....	....	....	....	....	......	0·33	0·72	1·05	1·04	16·85	" 11
C.........	0·0325	......	....	0·33	....	....	0·34	....	....	....	......	0·67	0·72	1·39	1·40	28·95	" 16
D.........	0·0330	0·33	....	....	0·34	....	....	....	....	....	......	0·67	0·72	1·39	1·44	38·60	" 16
E.........	0·0323	0·33	....	....	....	....	....	0·34	....	0·33	......	1·00	0·72	1·72	1·72	40·10	" 16
57 A.........	0·0330	0·33	....	0·34	....	....	....	....	....	....	0·33	1·00	0·78	1·78	1·42	45·99	" 23
B.........	0·0326	0·33	....	0·34	....	....	0·33	....	....	....	0·33	1·33	0·78	2·11	2·18	51·10	" 23
C.........	0·0336	......	....	0·33	....	....	0·50	....	....	....	......	0·88	0·78	1·66	1·70	38·35	" 23
D.........	0·0332	0·50	....	....	....	....	....	0·50	....	....	......	1·00	0·78	1·78	1·84	56·50	" 23
E.........	0·0332	0·50	....	....	....	....	....	0·50	....	0·50	......	1·50	0·78	2·28	2·28	7·50	" 23

ROTATION B

		May —	June 1	June 11	June 16	June 20	July 5	July 11	July	July 26	Aug. 1						
72 A...........	0·0247	......	....	....	....	....	....	....	....	....	......	......	0·72	0·72	0·62	22·7	Aug. 13
B...........	0·0286	......	....	0·33	....	....	....	....	....	....	......	0·33	0·78	1·11	1·16	41·3	" 23
C...........	0·0289	......	....	0·33	....	....	0·34	....	....	....	......	0·67	0·78	1·45	1·38	50·33	" 22
D...........	0·0297	......	0·33	....	....	0·34	....	....	....	....	......	0·67	0·78	1·45	1·66	50·7	" 22
E...........	0·0325	......	0·33	....	....	0·34	....	....	....	0·33	......	1·00	0·78	1·78	2·12	51·34	" 22
73 A...........	0·0317	......	0·33	....	0·34	0·33	....	....	....	....	0·33	1·33	0·78	2·11	2·25	47·7	" 22
B...........	0·0297	......	0·33	....	0·34	0·33	....	....	....	....	0·33	1·33	0·78	2·11	2·23	47·3	" 23
C...........	0·0296	......	....	0·50	....	....	0·50	....	....	....	......	1·00	0·78	1·78	1·93	44·15	" 23
D...........	0·0303	......	0·50	....	....	....	....	0·50	....	....	......	1·00	0·78	1·78	1·80	45·34	" 23
E...........	0·0380	......	0·50	....	....	....	....	0·50	....	0·50	......	1·50	0·78	2·28	2·06	45·3	" 23

ROTATION C

		May 30	June	June 13	June 20	June	July 5	July	July	July 26	Aug. 1						
86 A...........	......	......	....	....	....	....	....	....	....	....	......	......	0·72	0·72	0·61	10·00e	Aug. 16
B...........	0·0328	......	....	0·33	....	....	....	....	....	....	......	0·33	0·72	1·05	1·08	19·25	" 16
C...........	0·0340	......	....	0·33	....	....	....	....	....	....	......	0·33	0·72	1·05	1·24	17·60	" 16
D...........	0·0336	0·25	....	....	0·33	....	....	....	....	....	......	0·58	0·72	1·30	1·22	25·70	" 16
E...........	0·0292	0·25	....	....	0·33	....	....	....	....	0·33	......	0·91	0·72	1·63	1·44	36·33	" 16
85 A...........	0·0282	0·25	....	0·33	....	....	....	....	....	....	0·33	0·91	0·72	1·63	0·94	35·18	" 18
B...........	0·0338	0·25	....	0·33	....	....	0·34	....	....	....	0·33	1·25	0·72	1·97	1·51	32·64	" 18
C...........	0·0332	......	....	0·50	....	....	0·50	....	....	....	......	1·00	0·72	1·72	1·67	19·54	" 16
D...........	0·0336	0·50	....	....	0·50	....	....	....	....	....	......	1·00	0·72	1·72	1·82	28·10	" 18
E...........	0·0336	0·50	....	....	0·50	....	....	....	....	0·50	......	1·50	0·72	2·22	2·27e	31·00	" 18

ROTATION E

		May	June 5	June 14	June 19	July 6	July 9	July 14	July 20	July 29	Aug. 2						
7 B...........	0·0390	......	....	....	....	....	....	....	....	....	......	......	0·72	0·72	0·55	9·92	Aug. 13
6	0·2420	......	....	0·33	....	....	....	....	....	....	......	0·33	0·72	1·05	0·90	32·60	" 17
5	0·2330	......	....	0·33	....	0·34	0·34	....	....	....	......	0·67	0·78	1·45	1·44	37·80	" 23
4	0·2350	......	0·33	....	....	....	....	0·34	....	....	......	0·67	0·78	1·45	1·37	41·60	" 23
3	0·2350	......	0·33	....	....	....	....	0·34	....	0·33	......	1·00	0·78	1·78	1·76	40·20	" 23
2	0·2380	......	0·33	....	0·34	....	....	....	....	....	0·33	1·00	0·78	1·78	1·90	50·15	" 23
7 A...........	0·1130	......	0·33	....	0·34	....	....	....	....	....	0·33	1·00	0·78	1·78	1·72	46·00	" 23
1	0·2370	......	0·33	....	0·34	....	0·33	....	0·34	....	0·33	1·67	0·78	2·45	2·36	47·70	" 23
10	0·2390	......	....	0·50	....	0·50	....	....	....	....	......	1·00	0·72	1·72	1·76	47·70	" 17
9	0·2380	......	0·50	....	....	....	....	0·50	....	....	......	1·00	0·78	1·78	1·85	46·80	" 23
8	0·2380	......	0·50	....	....	....	....	0·50	....	0·50	......	1·50	0·78	2·28	2·31	49·70	" 23

Oats (Banner), 1923—Irrigation Experiment Station, Brooks, Alberta

ROTATION D

PLOT SERIES RECORD

	Area	Irrigation Date and Depth Applied in Acre-feet per Acre										Duty of Water	Rainfall April First to Harvest	Total Depth Received	Total Depth used in Growing Crop	Yield per acre	Remarks
	Acres	May	June				July				Aug.						
			1	14	16	21	5	11		26	1						
												Ft.	Ft.	Ft.	Ft.	Bus.	Harvested
82	0·0745												0·65	0·65	0·64	26·8	Aug. 2
80 A	0·0324			0·33								0·33	0·65	0·98	1·27	90·0e	“ 2
B				0·33			0·34					0·67	0·65	1·3[illegible]			“ 2
81 A	0·0276		0·33			0·34						0·67	0·7[illegible]	1·39	1·53	110·5	“ 17
B	0·0275		0·33					0·34		0·33		1·00	0·7[illegible]	1·72	1·77	130·[illegible]	“ 17
C	0·0336		0·33		0·34						0·33	1·00	0·7[illegible]	1·72	1·74	134·2	“ 17
D	0·0350		0·33		0·34		0·33				0·33	1·33	0·7[illegible]	2·05	1·87	128·5	“ 17
E	0·0316			0·50			0·50					1·00	0·72	1·72	1·77	135·0	“ 17
F	0·0408		0·50					0·50				1·00	0·72	1·72	1·66	126·5	“ 17
G	0·0378		0·50					0·50		0·50		1·50	0·72	2·22	2·45	108·0	“ 17

ROTATION B

		May	June				July				Aug.						
			1	13	16		5	11		26	2						
58 A	0·0287												0·72	0·72	0·91	97·0	Aug. 17
B	0·0282			0·33				0·34				0·67	0·72	1·39	1·61	96·6	“ 17
C	0·0281			0·33			0·34					0·67	0·72	1·39	1·44	111·5	“ 17
D	0·0270		0·33					0·34				0·67	0·72	1·39	1·09	110·5	“ 17
E	0·0258		0·33					0·34		0·33		1·00	0·78	1·78	1·33	112·5	“ 22
59 A	0·0334		0·33		0·34						0·33	1·00	0·78	1·78	1·81	116·2	“ 22
B	0·0347		0·33		0·34		0·33				0·33	1·33	0·78	2·11	1·45	122·2	“ 22
C	0·0353			0·50			0·50					1·00	0·78	1·78	1·80	119·3	“ 22
D	0·0354		0·50					0·50				1·00	0·78	1·78	1·69	123·5	“ 22
E	0·0352		0·50					0·50		0·50		1·50	0·78	2·28	2·36	118·5	“ 22

ROTATION E

		May	June				July				Aug.						
			5	14	19		6	9	13	29	2						
14 B	0·0937												0·65	0·65	0·78	21·3	Aug. 2
15	0·2000			0·33								0·33	0·65	0·98	1·08	49·4e	“ 2
16	0·2350			0·33			0·34					0·67	0·72	1·39	1·34	62·2	“ 11
17	0·2380		0·33						0·34			0·67	0·72	1·39	1·40	70·4	“ 17
18	0·2390		0·33						0·34	0·33		1·00	0·72	1·72	1·79	74·4	“ 17
19	0·2370		0·33		0·34						0·33	1·00	0·72	1·72	1·55	79·0	“ 17
14 A	0·1190		0·33		0·34						0·33	1·00	0·72	1·72	1·53	73·7	“ 16
20	0·2360		0·33		0·34			0·33			0·33	1·33	0·72	2·05	2·07	81·2	“ 17
11	0·2389			0·42			0·50					0·92	0·72	1·64	1·78	77·0	“ 16
12	0·2390		0·50						0·50			1·00	0·72	1·72	1·95	79·0	“ 16
13	0·2410		0·50						0·50	0·50		1·50	0·72	2·22	2·28	90·5	“ 16

ROTATION B 1

		May	June				July				Aug.						
			1	13	16	20	5			26	2						
70 A	0·0148												0·65	0·65	0·81	20·8	Aug. 2
B	0·0141			0·33								0·33	0·65	0·98	0·98	42·6	“ 2
C	0·0238			0·33			0·34					0·67	0·78	1·45	1·62	96·5	“ 22
D	0·0240		0·33			0·34						0·67	0·78	1·45	1·68	99·3	“ 22
E	0·0236		0·33			0·34				0·33		1·00	0·78	1·78	2·05	107·0	“ 22
71 A	0·0365		0·33		0·34						0·33	1·00	0·57	1·57	1·78	69·0	“ 18
B	0·0264		0·33		0·34		0·33				0·33	1·33	0·78	2·11	2·35	91·0	“ 22
C	0·0272			0·50			0·50					1·00	0·78	1·78	1·43	98·5	“ 22
D	0·0275		0·50			0·50						1·00	0·78	1·78	1·81	95·0	“ 22
E	0·0266		0·50			0·50				0·50		1·50	0·78	2·28	2·49	124·0	“ 22

Barley (O.A.C. 21), 1923—Irrigation Experiment Station, Brooks, Alberta

ROTATION D

PLOT SERIES RECORD

Plot No.	Area Acres	Irrigation Date and Depth Applied in Acre-feet per Acre									Duty of Water	Rainfall Apr. 1 to Harvest	Total Depth Received	Total Depth used in Growing Crop	Yield per Acre	Remarks
		June				July				Aug.						
		9	16	20	25	6	11	19	26	1						
											Ft.	Ft.	Ft.	Ft.	Bus.	Harvested
78 A												0·72	0·72	1·10		
B	0·0305		0·33								0·33	0·72	1·05	1·10e	44·5	Aug. 11
C	0·0297		0·33			0·34					0·67	0·72	1·39	1·45e	44·1	" 11
D	0·0290	0·33		0·34				0·33			1·00	0·72	1·72	1·83	40·2	" 11
E	0·0220	0·33		0·34				0·33	0·33		1·33	0·72	2·05	2·18	46·0	" 11
79 A	0·0297	0·33			0·34					0·33	1·00	0·72	1·72	1·74	50·7	" 11
B	0·0298	0·33			0·34		0·33			0·33	1·33	0·72	2·05	2·27	50·8	" 11
C	0·0300		0·50			0·50					1·00	0·72	1·72	1·60	49·2	" 11
D	0·0293	0·50		0·50				0·50			1·50	0·72	2·22	1·65	49·1	" 11
E	0·0301	0·50		0·50				0·50	0·50		2·00	0·72	2·72	2·71	59·2	" 11

ROTATION E

		June			July					Aug.						
		10	19	25	....	9	13	19	29	2						
30 A	0·0900											0·65	0·65	0·58	15·2	Aug. 2
26	0·2090		0·33								0·33	0·65	0·98	0·92	22·9	" 2
25	0·2370		0·33			0·34					0·67	0·69	1·36	1·09	29·1	" 10
24	0·2350	0·33						0·34			0·67	0·69	1·36	1·31	33·5	" 10
23	0·2360	0·33						0·34	0·33		1·00	0·69	1·69	1·60e	38·1	" 10
22	0·2330	0·33		0·04						0·34	0·71	0·69	1·40	1·22	38·2	" 10
27	0·2360	0·33		0·08						0·34	0·75	0·69	1·44	1·76	35·5	" 10
21	0·2360	0·33		0·17			0·34			0·33	1·17	0·69	1·86	1·81	36·8	" 10
30	0·1690		0·50			0·50					1·00	0·69	1·69	1·73	32·4	" 10
29	0·1950	0·50						0·50			1·00	0·69	1·69	1·74	35·0	" 10
28	0·2280	0·50						0·50	0·50		1·50	0·69	2·19	2·40	35·4	" 10

ROTATION C

		June				July				Aug.						
		7	16	21	....	5	11	19	26	1						
87 A	0·0316											0·72	0·72	0·60	10·8	Aug. 11
B	0·0340		0·33								0·33	0·72	1·05	1·02	27·9	" 11
C	0·0339		0·33		0·34						0·67	0·72	1·39	1·43	46·6	" 11
D	0·0337	0·33						0·34			0·67	0·72	1·39	1·33	30·8	" 11
E	0·0296	0·33						0·34	0·33		1·00	0·72	1·72	1·35	51·1	" 11
88 A												0·72	0·72			" 11
B	0·0337	0·33		0·34			0·33			0·33	1·33	0·72	2·05	1·68		" 11
C	0·0347		0·33		0·50						1·16	0·72	1·88	1·85	45·2	" 11
D	0·0342	0·50						0·50			1·00	0·72	1·72	1·52	48·4	" 11
E	0·0298	0·50						0·50	0·50		1·50	0·72	2·22	1·75	43·4	" 11

Flax, 1923—Irrigation Experiment Station, Brooks, Alberta

ROTATION A

PLOT SERIES RECORD

Plot No.	Area Acres	Irrigation Date and Depth Applied in Acre-feet per Acre								Duty of Water	Rainfall Apr. 1 to Harvest	Total Depth Received	Total Depth used in Growing Crop	Yield per acre	Remarks
		June			July				Aug.						
		9	16	25	6	11	19	26	2						
															Harvested
54 A	0·0278										0·78	0·78	0·78	7·05	Aug. 23
B	0·0308		0·33							0·33	0·79	1·12	1·10	17·10	" 28
C	0·0293		0·33		0·34					0·67	0·79	1·46	1·61	16·30	Sept. 3
D	0·0300	0·33					0·34			0·67	0·79	1·46	1·76	20·80	" 3
E	0·0293	0·33					0·33	0·33		1·00	0·79	1·79	1·74	24·10	" 3
55 A	0·0296	0·33		0·34					0·33	1·00	0·79	1·79	1·81	20·00	" 3
B	0·0318	0·33		0·34		0·33			0·33	1·33	0·79	2·12	2·16	20·40	" 3
C	0·0309		0·50		0·50					1·00	0·79	1·79	1·64	11·30	Aug. 28
D	0·0299	0·50					0·33			0·83	0·79	1·62	1·66	18·40	Sept. 3
E	0·0322	0·50					0·33	0·50		1·33	0·79	2·12	2·24	15·99	" 3

Alfalfa Hay (Grimm), 1923—Irrigation Experiment Station, Brooks, Alberta

ROTATION A, SEEDED 1920

PLOT SERIES RECORD

Plot No.	Area Acres	Irrigation Date and Depth Applied in Acre-feet per Acre								Duty of Water	Rainfall April 1 to Harvest	Total Depth Received	Total Depth Used in Growing Crop	Yield per Acre	Remarks
		May		June		July		August							
		18		6	18	21	27	2	13	Ft.	Ft.	Ft.	Tons	Tons	
46A	0·0127	......	......	......	......	......	......	......	......	......	0·79	0·79	1·01	0·951	1st cut
B	0·0269	......	......	......	0·50	......	......	......	......	0·50	0·79	1·29	1·32	1·390	July 10
C	0·0330	......	......	0·50	......	0·50	......	......	......	1·00	0·79	1·79	1·75	3·210	2nd cut
D	0·0322	......	......	0·50	......	0·50	......	......	......	1·00	0·79	1·79	1·74	4·086	Aug. 30
E	0·0300	0·50	......	......	0·50	......	0·50	......	......	1·50	0·79	2·29	2·34	5·618	
47A	0·0296	0·50	......	......	0·50	......	......	0·50	......	1·50	0·79	2·29	2·48	5·916	
B	0·0302	0·50	......	......	0·50	......	......	0·50	0·50	2·00	0·79	2·79	2·66	5·760	
C	0·0314	0·33	......	......	0·34	......	......	......	......	0·67	0·79	1·46	1·49	4·731	
D	0·0297	0·33	......	......	0·34	......	......	0·33	......	1·00	0·79	1·79	1·69	5·820	
E	0·0306	0·33	......	......	0·34	......	......	0·33	0·33	1·33	0·79	2·12	1·99	5·158	

ROTATION A, SEEDED 1921

		May		June		July		August							
		18		13	16	21	27	2	13						
48A	0·0172	......	......	......	......	......	......	......	......	......	0·79	0·79	0·81	0·537	1st cut
B	0·0267	......	......	......	0·50	......	......	......	......	0·50	0·79	1·29	1·24	3·071	July 10
C	0·0288	0·50	......	0·50	......	0·50	......	......	......	1·50	0·79	2·29	2·30	4·750	2nd cut
D	0·0284	0·50	......	......	......	0·50	......	......	......	1·00	0·79	1·79	1·86	4·029	Aug. 30
E	0·0612	0·50	......	......	0·50	......	0·50	......	......	1·50	0·79	2·29	1·97	5·867	
49A	0·0294	0·50	......	......	0·50	......	......	0·50	......	1·50	0·79	2·29	2·53	5·400	
B	0·0294	0·50	......	......	0·50	......	......	0·50	0·50	2·00	0·79	2·79	2·74	5·640	
C	0·0301	0·33	......	......	0·34	......	......	......	......	0·67	0·79	1·46	1·62	3·953	
D	0·0294	0·33	......	......	0·34	......	......	0·33	......	1·00	0·79	1·79	1·73	4·010	
E	0·0309	0·33	......	......	0·34	......	......	0·33	0·33	1·33	0·79	2·12	2·19	5·454	

ROTATION A, SEEDED 1922

		May		June		July		August							
		19	28	13	16	21	27	2	13						
50A	0·0307	......	......	0·25	......	0·25	......	......	......	0·50	0·79	1·29	1·26	3·080	1st cut
B	0·0309	......	0·50	......	......	0·50	......	......	......	1·00	0·79	1·79	1·55	3·770	July 10
C	0·0297	0·33	......	......	0·50	......	0·50	......	......	1·33	0·79	2·12	2·25	4·415	2nd cut
D	0·0308	0·33	......	......	0·33	......	......	0·50	......	1·16	0·79	1·95	1·99	4·447	Aug. 30
E	0·0299	0·50	......	......	0·50	......	......	0·50	0·50	2·00	0·79	2·79	2·92	4·477	
51A	0·3016	......	......	......	......	......	......	......	......	......	0·79	0·79	1·42	......	
B	0·0307	......	......	......	0·50	......	......	......	......	0·50	0·79	1·29	1·42	2·050	
C	0·0313	0·33	......	......	0·34	......	......	......	......	0·67	0·79	1·46	1·64	2·465	
D	0·0301	0·33	......	......	0·34	......	......	0·33	......	1·00	0·79	1·79	1·96	3·949	
E	0·0295	0·33	......	......	0·34	......	......	0·32	0·33	1·33	0·79	2·12	2·49	3·983	

Grass Hay (Mixture), 1923—Irrigation Experiment Station, Brooks, Alberta

ROTATION C

PLOT SERIES RECORD

Plot No.	Area Acres	Irrigation Date and Depth Applied in Acre-feet per Acre								Duty of Water	Rainfall April 1 to Harvest	Total Depth Received	Total Depth used in Growing Crop	Yield per Acre	Remarks
		May			June										
		16	17	28	6	12	15	18	20						
										Ft.	Ft.	Ft.	Ft.	Tons	Harvested
91–92A	0·0331	......	......	......	......	......	......	......	......	......	0·49	0·49	0·64	0·725	July 5
B	0·0315	......	0·33	......	......	......	......	......	......	0·23	0·49	0·82	0·80	0·762	" 5
C	0·0296	......	0·33	......	......	0·34	......	......	......	0·67	0·49	1·16	1·08	1·216	" 5
D	0·0279	......	0·33	......	0·34	......	......	......	0·33	1·00	0·49	1·49	1·35	1·720	" 5
E	0·0251	......	0·33	......	0·34	......	......	......	0·33	1·00	0·49	1·49	1·52	1·515	" 5
F	0·0257	......	0·33	0·34	......	......	0·33	......	......	1·00	0·49	1·49	1·44	1·362	" 5
G	0·0405	......	......	0·33	0·34	0·33	......	0·33	......	1·33	0·49	1·82	1·58	0·740	" 5
H	0·0435	......	0·50	......	......	0·50	......	......	......	1·00	0·49	1·49	1·45	0·713	" 5
K	0·0495	......	0·50	......	0·50	......	......	......	0·50	1·50	0·49	1·99	1·95	1·010	" 5
L	0·0437	......	0·50	......	0·50	......	......	......	0·50	1·50	0·49	1·99	1·39	0·550	" 5
93–94A	0·0353	......	......	......	......	......	......	......	......	......	0·49	0·49	0·58	0·595	" 5
B	0·0405	0·33	......	......	......	......	......	......	......	0·33	0·49	0·82	0·93	......	" 5
C	0·0388	0·33	......	......	......	0·34	......	......	......	0·67	0·49	1·16	1·21	1·65	" 5
D	0·0506	0·33	......	......	0·34	......	......	......	0·33	1·00	0·49	1·49	1·11	1·26	" 5
E	0·0615	0·33	......	......	0·34	......	......	......	0·33	1·00	0·49	1·49	1·34	......	" 5
F	0·0695	0·33	......	0·34	......	......	0·33	......	......	1·00	0·49	1·49	1·76	1·26	" 5
G	0·0310	0·33	......	0·34	......	0·33	......	0·33	......	1·33	0·49	1·82	1·91	0·95	" 5
H	0·0256	0·50	......	......	......	0·50	......	......	......	1·00	0·49	1·49	1·59	1·60	" 5
K	0·0403	0·50	......	......	0·50	......	......	......	0·50	1·50	0·49	1·99	1·90	1·28	" 5
L	0·0387	0·50	......	......	0·50	......	......	......	0·50	1·50	0·49	1·99	2·11	1·20	" 5

Corn (N.W. Dent), 1923—Irrigation Experiment Station, Brooks, Alberta

ROTATION B

PLOT SERIES RECORD

Plot No.	Area Acres	Irrigation Date and Depth Applied in Acre-feet per Acre								Duty of Water	Rainfall April 1 to Harvest	Total Depth Received	Total Depth used in Growing Crop	Yield per Acre	Remarks
		July				August									
		5	12	19	27	2	6	11	13						
										Ft.	Ft.	Ft.	Ft.	Bush.	Harvested
60A	0·0109	......	......	......	......	......	......	......	......	......	0·79	0·79	0·23	4·44	Sept. 26
B	0·0350	......	0·17	......	......	......	......	......	......	0·17	0·79	0·96	......	6·05	" 26
C	0·0360	0·17	......	0·17	......	......	......	......	......	0·34	0·79	1·13	1·03	7·60	" 26
D	0·0366	......	0·17	......	......	0·17	......	......	......	0·34	0·79	1·13	1·18	6·67	" 26
E	0·0381	......	0·17	......	......	0·16	......	0·17	......	0·50	0·79	1·29	0·92	6·95	" 26
61A	......	0·17	......	0·16	......	......	0·17	......	0·17	0·67	0·79	1·46	1·30	......	" 26
B	0·0346	0·25	......	0·17	0·16	......	0·17	......	0·17	0·92	0·.9	1·71	1·49	5·74	" 26
C	0·0362	0·25	......	0·25	......	......	......	......	......	0·50	0·79	1·29	1·22	6·72	" 26
D	0·0356	......	0·25	......	......	0·25	......	......	......	0·50	0·79	1·29	0·97	7·77	" 26
E	0·0367	......	0·25	......	......	0·25	......	0·25	......	0·75	0·79	1·54	......	6·58	" 26

Peas (Prussian Blue), 1923—Irrigation Experiment Station, Brooks, Alberta

ROTATION E

PLOT SERIES RECORD

Plot No.	Area Acres	Irrigation Date and Depth Applied in Acre-feet per Acre										Duty of Water	Rainfall April 1 to Harvest	Total Depth Received	Total Depth used in Growing Crop	Yield per Acre	Remarks
		June				July				August							
		2	13	17	29	5	9	12	28	2	11						
												Ft.	Ft.	Ft.	Ft.	Bush.	Harvested
32	0·[illegible]87	....	....	....	....	....	....	....	....	....	....	....	0·65	0·65	0·68	10·3	Aug. 2
31	0·0456	....	0·33	....	....	....	....	....	....	....	....	0·33	0·72	1·05	1·03	14·6	" 13
36	0·235	....	0·33	....	....	0·50	....	....	....	....	....	0·83	0·78	1·61	1·45	24·8	" 24
37	0·224	0·33	....	....	....	....	....	0·34	....	....	....	0·67	0·78	1·45	1·62	29·7	" 24
38	0·229	0·33	....	....	....	....	....	0·34	0·33	....	....	1·00	0·78	1·78	2·06	32·0	" 24
39	0·218	0·33	....	0·34	....	....	....	....	....	0·33	....	1·00	0·78	1·78	1·89	34·8	" 24
40	0·229	0·33	....	0·34	....	....	0·33	....	....	0·33	....	1·33	0·78	2·11	2·23	34·2	" 24
32A	0·115	0·33	0·34	....	0·33	....	....	0·34	....	0·33	....	1·67	0·78	2·45	2·64	34·8	" 24
B	0·081	0·33	0·34	....	0·33	....	....	0·34	....	0·33	0·33	2·00	0·78	2·78	2·79	24·7	" 24
33	0·0377	....	0·50	....	....	0·50	....	....	....	....	....	1·00	0·72	1·72	1·83	29·6	" 16
34	0·067	0·50	....	....	....	....	....	0·50	....	....	....	1·00	0·78	1·78	1·70	33·4	" 24
35	0·0485	0·50	....	....	....	....	....	0·50	0·50	....	....	1·50	0·78	2·28	1·99	23·0	" 24

Potatoes (Gold Coin), 1923—Irrigation Experiment Station, Brooks, Alberta

ROTATION A

PLOT SERIES RECORD

Plot No.	Area	Irrigation Date and Depth Applied in Acre-feet per Acre										Duty of Water	Rainfall April 1 to Harvest	Total Depth Received	Total Depth used in Growing Crop	Yield per Acre	Remarks
	Acres	July					August			Sept.							
		7	12	19	21	27	7	14	20	1	6						
												Ft.	Ft.	Ft.	Ft.	Bush.	Harvested
42A	0·0349	....	....	....	....	....	....	....	....	....	....	......	0·79	0·79	0·80	163·7	Oct. 3
B	0·0362	....	0·17	....	....	....	....	....	....	....	....	0·17	0·79	0·96	0·84	181·5	" 3
C	0·0358	....	....	....	....	....	0·17	....	....	....	....	0·17	0·79	0·96	0·82	151·5	" 3
D	0·0367	....	....	0·17	....	....	....	0·17	....	....	....	0·34	0·79	1·13	1·08	208·0	" 3
E	0·0345	0·17	....	....	....	....	0·16	....	....	....	0·17	0·50	0·79	1·29	1·41	216·8	" 3
43A	0·0362	0·17	....	....	....	0·16	....	0·17	....	0·17	....	0·67	0·79	1·46	1·55	e441·1	" 3
B	0·0360	0·17	....	....	0·17	....	0·17	....	0·17	0·17	....	0·85	0·79	1·64	1·75	e470·4	" 3
C	0·0352	....	....	....	....	0·25	0·25	....	....	....	....	0·50	0·79	1·29	1·07	258·4	" 3
D	0·0362	....	....	0·25	....	....	....	0·25	....	....	....	0·50	0·79	1·29	2·13	227·1	" 3
E	0·0345	0·25	....	....	....	....	0·25	....	....	....	0·25	0·75	0·79	1·54	1·82	231·0	" 3

ROTATION C

PLOT SERIES RECORD

Plot No.	Area	Irrigation Date and Depth Applied in Acre-feet per Acre										Duty of Water	Railfall April 1 to Harvest	Total Depth Received	Toral Depth Used in Growing Crop	Yield per Acre	Remarks
	Acres	July					August			Sept.							
		6	11	19	21	26	6	13	20	1	6						
												Ft.	Ft.	Ft.	Ft.	Bush.	Harvested
89-90A	0·0308	....	0·17	....	....	....	....	....	....	....	...	......	0·79	0·79	0·64	171·9	Oct. 4
B	0·0359	....	0·17	....	....	....	....	....	....	....	....	0·17	0·79	0·96	0·98	192·1	" 4
C	0·0355	....	....	....	....	....	0·17	....	....	....	....	0·17	0·79	0·96	1·03	198·7	" 4
D	0·0355	....	....	0·17	....	....	....	0·17	....	....	....	0·34	0·79	1·13	1·25	253·5	" 4
E	0·0355	0·17	....	....	....	....	0·16	....	....	....	0·17	0·50	0·79	1·29	1·60	e357·6	" 4
F	0·0355	0·17	....	....	....	0·16	....	0·17	....	0·17	....	0·67	0·79	1·46	1·65	e372·1	" 4
G	0·0355	0·17	....	....	0·17	....	0·17	....	0·17	0·17	....	0·85	0·79	1·64	1·73	366·43	" 4
H	0·0355	....	....	....	....	....	0·25	....	....	....	....	0·25	0·79	1·04	1·28	197·5	" 4
J	0·0351	....	....	0·25	....	....	....	0·25	....	....	....	0·50	0·79	1·29	1·21	183·33	" 4
K	0·0339	0·25	....	....	....	....	0·25	....	....	....	0·25	0·75	0·79	1·54	1·75	337·3	" 4

Alfalfa Seed (Grimm Lymans'), 1923—Irrigation Experiment Station, Brooks, Alberta

PLOT SERIES RECORD

Plot No.	Area	Irrigation Date and Depth Applied in Acre-feet per Acre					Duty of Water	Rainfall April 1 to Harvest	Total Depth Received	Total Depth used in Growing Crop	Yield per Acre	Remarks
	Acres	June	July			Aug.						
		12	10	14	23	1						
							Ft.	Ft.	Ft.	Ft.	Lbs.	Harvested
107A	0·0287	......	......	......	......	......	......	0·78	0·78	0·96	23·94	Aug. 24
B	0·0564	0·25	......	......	......	......	0·25	0·79	1·04	1·11	28·40	Sept. 25
C	0·0488	0·25	......	......	......	......	0·25	0·79	1·04	1·16	32·58	" 25
D	0·0644	0·25	0·25	......	......	......	0·50	0·79	1·29	1·48	54·74	" 25
E	0·0650	0·25	0·25	......	0·25	......	0·75	0·79	1·54	1·60	4·83	" 25
F	0·0524	0·25	......	0·25	0·25	0·25	1·00	0·79	1·79	1·88	55·92	" 25

Alfalfa Seed (Grimm), 1923—Irrigation Experiment Station, Brooks, Alberta

PLOT SERIES RECORD

Plot No.	Area Acres	Irrigation Date and Depth Applied in Acre-feet per Acre				Duty of Water	Rainfall April 1 to Harvest	Total Depth Received	Total Depth Used in Growing Crop	Yield per Acre	Remarks
		June	July		Aug.						
		12	10	23	1						
						Ft.	Ft.	Ft.	Ft.	Lbs.	Harvested
103A	0·0690	0·25	......	......	......	0·25	0·79	1·04	1·30	117·7	Sept. 25
B	0·0692	0·25	......	......	......	0·25	0·79	1·04	1·29	......	Sept. 25
C	0·0692	0·25	......	......	......	0·25	0·79	1·04	1·52	54·2	Sept. 25
D	0·0692	0·25	0·25	......	......	0·50	0·79	1·29	1·58	156·1	Sept. 25
E	0·0695	0·25	0·25	0·25	......	0·75	0·81	1·56	1·69	111·5	Oct. 11
F	0·0695	0·25	0·25	0·25	0·25	1·00	0·81	1·81	2·09	107·9	Oct. 11

Alfalfa Seed (Grimm Lymans'), 1923—Irrigation Experiment Station, Brooks, Alberta

PLOT SERIES RECORD

Plot No.	Area Acres	Irrigation Date and Depth Applied in Acre-feet per Acre					Duty of Water	Rainfall April 1 to Harvest	Total Depth Received	Total Depth Used in Growing Crop	Yield per Acre	Remarks
		May	June	July								
		19	13		21							
							Ft.	Ft.	Ft.	Ft.	Lbs	Harvested
64A	0·0181	......	......	......	......	......	......	0·78	0·78	1·18	32·46	Aug. 24
B	0·0226	0·25	0·25	......	......	......	0·50	0·78	1·28	1·49	24·20	" 24
C	0·0237	0·25	0·25	......	......	......	0·50	0·78	1·28	1·46	23·23	" 24
D	0·0251	0·25	0·25	......	......	......	0·50	0·78	1·28	1·41	11·84	" 25
E	0·0263	0·25	0·25	......	0·25	......	0·75	0·78	1·53	1·83	18·27	" 25

Alfalfa Seed (Grimm Lymans'), 1923—Irrigation Experiment Station, Brooks, Alberta

PLOT SERIES RECORD

Plot No.	Area Acres	Irrigation Date and Depth Applied in Acre-feet per Acre				Duty of Water	Rainfall April 1 to Harvest	Total Depth Received	Total Depth Used in Growing Crop	Yield per Acre	Remarks
		June	July		Aug.						
		12	10	23	1						
						Ft.	Ft.	Ft.	Ft.	Lbs.	Harvested
102A	0·0670	0·25	......	......	......	0·25	0·79	1·04	1·72	66·3	Sept. 25
B	0·0670	0·25	......	......	......	0·25	0·79	1·04	1·17	......	" 25
C	0·0672	0·25	......	......	......	0·25	0·79	1·04	1·19	32·7	" 25
D	0·0675	0·25	0·25	......	......	0·50	0·79	1·29	1·54	70·4	" 25
E	0·0700	0·25	0·25	0·25	......	0·75	0·81	1·56	1·81	71·5	Oct. 11
F	0·0700	0·25	0·25	0·25	0·25	1·00	0·81	1·81	1·85	32·2	" 11

Alfalfa Seed (Grimm), 1923—Irrigation Experiment Station, Brooks, Alberta

PLOT SERIES RECORD

Plot No.	Area Acres	Irrigation Date and Depth Applied in Acre-feet per Acre				Duty of Water	Rainfall April 1 to Harvest	Total Depth Received	Total Depth Used in Growing Crop	Yield per Acre	Remarks
		June	July		Aug.						
		9	11	27	1						
						Ft.	Ft.	Ft.	Ft.	Lbs.	Harvested
44C	0·0240	0·33	......	0·25	......	0·58	0·79	1·37	1·73	63·88	Sept. 26
44B	0·0232	0·33	......	......	......	0·33	0·79	1·12	1·66	33·14	" 26
63A	0·0242	0·33	......	0·25	......	0·58	0·79	1·37	2·43	......	" 25
62A	0·0095	......	......	......	......	0·00	0·78	0·78	1·03	169·3	Aug. 24
62C	0·0310	0·33	0·25	......	......	0·58	0·79	1·37	1·53	90·6	Sept. 25
44D	0·0253	0·33	0·25	......	......	0·58	0·79	1·37	1·55	12·33	" 26
63B	0·0282	0·33	0·25	......	......	0·58	0·79	1·37	2·34	......	" 25
62D	0·0297	0·33	0·25	0·25	......	0·83	0·79	1·62	1·78	59·0	" 25
62E	0·0266	0·33	0·25	0·25	......	0·83	0·79	1·62	1·93	33·0	" 25
63E	0·0264	0·33	0·25	0·25	......	0·83	0·79	1·62	2·25	......	" 25
44E	0·0237	......	0·33	......	......	0·33	0·79	1·12	1·23	13·79	" 26

Alfalfa Seed (Grimm), 1923—Irrigation Experiment Station, Brooks, Alberta

PLOT SERIES RECORD

Plot No.	Area Acres	Irrigation Date and Depth Applied in Acre-feet per Acre				Duty of Water	Rainfall April 1 to Harvest	Total Depth Received	Total Depth Used in Growing Crop	Yield per Acre	Remarks
		June	July		Aug.						
		9	12	27	6						
						Ft.	Ft.	Ft.	Ft.	Lbs.	Harvested
63C	0·0297	0·50	......	......	0·25	0·75	0·79	1·54	2·14	......	
45C	0·0263	0·50	......	0·25	......	0·75	0·79	1·54	1·93	19·0	Sept. 26
45B	0·0263	0·33	0·25	0·25	0·25	1·08	0·79	1·87	1·81	52·5	" 26
45A	0·0169	0·33	......	......	0·25	0·58	0·79	1·37	1·45	......	
45D	0·0275	......	......	......	0·25	0·25	0·79	1·04	1·86	36·4	" 26
45E	0·0260	......	......	0·25	0·25	0·50	0·79	1·29	1·80	......	
63D	0·0289	0·50	......	......	......	0·50	0·79	1·29	1·80	10·7	" 25
62B	0·0272	0·50	......	......	......	0·50	0·78	1·28	1·40	......	
44A	0·0171	......	......	......	......	0·00	0·79	0·79	1·12	20·2	Aug. 24

Meteorological Data

—	Precipitation									
	1914	1915	1916	1917	1918	1919	1920	1921	1922	1923
	Feet	Feet	Feet	Feet	Feet	Feet	Feet	Feet	Feet	Feet
Strathmore	0·71	1·44	1·33	0·85	0·48	1·09	0·74	0·75	0·83	1·20
Ronalane	0·38	0·93	1·32	0·50	0·38	0·57	0·45	0·56	0·60	0·94
Coaldale	0·57	1·32	1·56	0·72	0·37	0·64	0·84	0·55	0·73	1·03
Brooks	......	......	......	0·57	0·32	0·70	0·41	0·69	0·70	0·79

	Temperature									
	1914	1915	1916	1917	1918	1919	1920	1921	1922	1923
	°F	°F	°F	°F	°F	°F	°F	°F	°F	°F
Strathmore	52·4	52·6	50·6	52·0	52·8	52·8	51·0	52·6	52·9	52·7
Ronalane	59·4	57·1	55·2	55·8	56·8	58·4	56·0	57·5	58·7	57·1
Coaldale	55·9	55·4	54·5	55·4	55·9	56·7	54·7	55·4	56·8	56·9
Brooks	55·6	56·3	54·7	56·3	58·0	57·5	55·6	56·1	57·2	57·3

—	Precipitation		Temperature	
	1914–1923	Long Term	1914–1923	Long Term
	Feet	Feet	°F	°F
Calgary	0·85	1·01	54·23	52·58
Medicine Hat	0·73	0·77	59·48	59·12
Lethbridge	0·83	0·96	54·86	55·61

Calgary—index for Strathmore—long term records 1885–1923. Medicine Hat—index for Ronalane and Brooks—long term records 1884–1923. Lethbridge—index for Coaldale—long term records 1903–1923.

Diagram Showing Typical Soils

	Strathmore	Ronalane	Coaldale	Brooks
First Foot	Sandy Soil	Fine sandy loam soil	Clay Loam	Fine Sandy loam
Second Foot	Fine Sandy Soil to depth varying from 3 to 7 feet.	Sandy loam	Light clay loam very uniform, has no impervious stratum.	Very uniform soil, very fine sand and silt. Light gravel at 12 to 14 feet depth.
Third Foot				
Fourth Foot				
Fifth Foot	Heavy clay and gumbo subsoil. Very impervious	Sand and Gravel		
Sixth Foot				

Table Showing Comparisons between Coaldale, Ronalane, Brooks and Strathmore for Temperature, Precipitation and Evaporation

NW. 25-8-20—COALDALE EL. 2828·1

—	Evaporation								
	1915	1916	1917	1918	1919	1920	1921	1922	1923
April	5·68	1·51	2·55	3·20	6·59	3·31	2·05	1·97	3·19
May	4·28	5·12	4·83	6·76	5·20	5·68	3·69	4·32	4·63
June	2·26	4·68	5·78	7·88	7·30	6·47	6·62	5·17	3·30
July	4·38	6·20	9·20	7·68	8·12	6·92	6·55	5·45	4·42
August	4·97	4·70	5·23	6·79	6·91	5·76	6·09	5·42	3·90
September	2·93	3·59	4·35	3·76	3·81	4·80	4·28	4·40	3·85
Sums	24·50	25·80	31·94	36·07	37·93	32·94	29·28	26·73	23·29

	Precipitation								
April	0·00	0·26	0·70	0·15	0·53	3·54	0·54	2·93	1·12
May	2·99	4·12	0·86	1·03	1·86	1·59	1·28	1·28	3·16
June	5·31	3·82	2·11	0·65	0·66	1·09	0·86	1·24	3·51
July	5·15	2·47	0·29	0·93	1·27	3·21	2·17	2·25	3·18
August	0·28	3·25	1·88	1·23	1·20	0·29	0·55	0·33	1·30
September	2·11	4·79	2·82	0·41	2·14	0·31	1·21	0·73	0·09
Sums	15·84	18·71	8·66	4·40	7·66	10·03	6·61	8·76	12·36

	Temperature								
April	50·0	44·2	39·2	42·8	45·4	31·1	41·2	38·2	41·4
May	51·1	48·6	49·7	44·0	49·0	47·6	51·0	51·6	53·2
June	54·7	56·4	56·4	63·0	58·3	57·0	62·8	61·7	60·6
July	59·3	63·3	68·5	64·3	65·9	69·0	64·6	64·0	66·5
August	67·2	60·8	63·5	63·5	66·7	68·1	62·7	66·0	63·3
September	50·4	53·6	55·1	57·4	54·8	55·4	50·3	59·0	56·5
Averages	55·4	54·5	55·4	55·8	56·7	54·7	55·4	56·8	56·9

NW. 5-13-12—RONALANE EL. 2330

—	Precipitation								
	1915	1916	1917	1918	1919	1920	1921	1922	1923
April	0·09	0·14	0·84	0·21	2·34	0·90	0·61	2·48	0·93
May	1·69	2·33	0·76	0·65	1·62	1·54	1·74	0·80	1·63
June	4·15	4·32	1·29	1·22	0·37	0·66	0·74	1·73	5·12
July	3·26	4·24	0·24	1·37	0·89	2·22	1·21	1·10	2·34
August	0·75	1·68	1·34	0·92	0·77	0·00	0·57	0·48	1·32
September	1·29	3·14	1·53	0·22	0·83	0·03	1·96	0·59	0·00
Sums	11·23	15·85	6·00	4·59	6·82	5·35	6·83	7·18	11·34

	Temperature								
April	51·4	43·9	37·7	42·2	45·5	33·6	42·9	41·1	40·57
May	53·0	48·7	51·6	49·8	53·6	50·4	52·4	54·0	54·10
June	56·4	57·6	57·8	64·1	63·1	59·7	66·3	60·3	61·68
July	61·2	65·8	69·9	65·0	67·3	69·5	68·3	66·7	67·82
August	69·2	62·1	62·6	64·4	66·6	65·8	64·8	68·3	63·35
September	51·5	53·3	55·1	65·0	54·6	56·9	50·7	61·5	54·90
Averages	57·1	55·2	55·8	56·8	58·4	56·0	57·6	58·6	57·07

SE. 6-19-14—BROOKS EL. 2455

—	Evaporation								
	1915	1916	1917	1918	1919	1920	1921	1922	1923
April	....	....	....	5·68	2·47	1·05	2·64	1·71	3·73
May	....	....	....	8·47	6·07	4·28	3·69	4·73	4·89
June	....	....	....	8·50	7·33	5·73	5·77	4·52	3·22
July	....	....	....	9·57	7·15	5·15	6·29	5·35	5·13
August	....	....	....	6·80	5·21	5·65	6·01	4·64	3·18
September	....	....	....	3·84	3·21	4·12	3·22	2·82	3·12
Sums	....	....	....	42·86	31·44	25·98	27·62	23·77	23·27

	Precipitation								
April	....	....	0·58	0·00	1·41	1·16	0·95	1·94	0·78
May	....	....	1·01	0·42	1·02	0·88	1·55	1·26	0·90
June	5·41	2·27	0·89	0·54	0·40	1·52	0·21	2·09	4·19
July	1·55	2·61	1·06	1·39	1·46	1·41	1·44	0·33	1·87
August	2·07	1·80	2·45	1·15	2·40	0·00	1·46	1·70	1·75
September	0·65	2·45	0·82	0·31	1·77	0·00	2·65	1·12	0·00
Sums	....	....	6·81	3·81	8·46	4·97	8·26	8·44	9·49

	Temperature								
April	48·2	43·0	39·0	46·0	43·8	34·6	41·5	41·0	43·4
May	50·0	47·0	52·0	52·0	53·1	50·8	50·3	52·7	53·2
June	56·4	58·0	58·3	65·0	62·4	59·4	64·6	62·2	61·9
July	62·0	66·0	70·5	67·5	66·3	69·0	67·3	64·9	67·3
August	70·0	62·0	63·9	64·2	64·5	64·6	63·2	65·6	63·2
September	51·0	52·0	54·3	53·2	54·8	55·5	50·0	57·0	55·0
Averages	56·3	54·7	56·3	58·0	57·5	55·6	56·1	57·2	57·3

NE. 11-24-25—STRATHMORE EL. 3190

—	Evaporation								
	1915	1916	1917	1918	1919	1920	1921	1922	1923
April	4·22	2·59	2·09	2·88	4·15	2·05	3·00	....	3·69
May	4·73	3·46	3·70	4·58	6·42	3·00	4·76	5·85	5·43
June	4·33	4·59	4·60	5·83	6·42	4·20	6·02	4·24	3·50
July	6·47	4·84	5·88	6·13	5·46	4·47	6·27	5·33	4·76
August	4·25	3·16	3·66	4·01	3·65	4·47	3·59	3·74	3·37
September	2·27	2·66	2·27	2·62	1·64	3·67	2·69	3·56	2·44
Sums	26·27	21·30	22·20	26·05	27·74	21·86	26·33	....	23·19
	Precipitation								
April	0·11	0·44	0·56	0·39	1·45	2·11	1·28	2·71	1·06
May	3·42	4·51	3·26	1·08	2·26	1·78	0·71	0·36	3·97
June	4·77	2·02	2·30	0·22	1·10	1·72	1·14	1·30	4·02
July	4·89	3·42	0·51	1·10	1·56	2·87	2·70	2·15	2·56
August	1·48	3·13	2·48	2·10	3·46	0·27	2·99	2·73	1·98
September	2·56	2·60	1·05	0·82	3·26	0·08	0·63	0·76	0·83
Sums	17·23	16·12	10·16	5·71	13·09	8·83	9·44	10·01	14·42
	Temperature								
April	46·6	41·0	35·1	41·2	41·9	27·7	38·6	35·7	38·5
May	48·6	44·4	47·2	48·5	47·4	46·0	49·2	50·2	49·8
June	51·7	53·9	54·2	59·9	56·1	55·5	60·3	54·2	54·0
July	57·2	59·1	64·9	62·6	61·7	65·0	61·8	60·7	62·3
August	64·4	56·7	59·0	55·5	60·4	60·8	58·9	61·9	59·5
September	47·0	48·5	51·6	49·0	49·5	51·3	47·0	54·8	52·3
Averages	52·6	50·6	52·0	52·8	52·8	51·0	52·6	52·9	52·7

Summary of Temperature, Precipitation and Evaporation at Coaldale, Ronalane, Brooks and Strathmore, April to September inclusive

Station	Mean Temperature 9-Yr. Period 1915–23 inclusive	Precipitation 7-Yr. Period 1917–23 inclusive	Evaporation 6-Yr. Period 1918–23 inclusive
Coaldale	55·7	8·35	31·04
Ronalane	57·0	6·87	....
Brooks	56·6	7·18	29·16
Strathmore	52·2	10·24	....

Report on Drainage Surveys and Investigations

GENERAL

This season marked the fifth since the co-operative agreement between the provinces of Alberta and Saskatchewan and the Dominion regarding drainage became effective. Investigatory drainage survey work both by the Provincial and the Federal Governments was reduced to a minimum during the past season in observance of the policy of exercising strict economy. With the exception of the small drainage projects, no new drainage investigations were undertaken by the Dominion Water Power and Reclamation Service, all the field work being restricted to completing the field investigations of the large projects under investigation from last season.

As a result of the decrease in the work, the drainage field staff for this season was considerably reduced. The field organization was under the direct supervision of Mr. J. S. Tempest, Supervising Hydraulic Engineer; Mr. G. F. Horsey, Hydraulic Engineer, was in charge of the large party engaged in completing the survey of the Carrot River Triangle drainage project in northern Saskatchewan and Manitoba, while Messrs. A. C. Wright and W. C. Warren, Assistant Hydraulic Engineers, were in charge of construction parties on the Waterhen Lake drainage district in Saskatchewan. Mr. Wright in addition to his duties at Waterhen Lake district made investigations and inspections of a number of small drainage projects in Saskatchewan. Mr. D. Whittaker, Assistant Hydraulic Engineer, was engaged in making investigations and inspections of small drainage projects in the province of Alberta. His party returned to the field early in January, 1924, to undertake a survey to ascertain the feasibility of a comprehensive drainage development in the valley of the Whitemud creek in Alberta. This work was completed before the spring break-up. The other survey parties finished their season's work in December, 1923, when the senior engineers returned to Ottawa to prepare the reports and plans of the season's work.

Drainage projects are dealt with under three general classes:—

1. Small projects that are less than 1,280 acres in extent and under $5,000 in estimated cost. These may be undertaken by individuals.
2. Provincial Government projects which are initiated by groups of settlers under the provincial drainage laws for the co-operative carrying out of comprehensive drainage for the improvement of their own lands and any Crown land in the drainage district.
3. Large projects carried out by the Dominion Government where 50 per cent or more of the land to be reclaimed is in the control of the Crown.

The following is a brief summary of the work carried out last season:—

SMALL PROJECTS

Under the provisions of the Reclamation Acts of the provinces of Alberta and Saskatchewan, and the Dominion Government Drainage Regulations, small drainage projects may be carried out by settlers without recourse to the rather expensive procedure under the Provincial Private Ditches Act. In each such case, and without charge to the applicant, an engineer of the department investigates the projet to determine its feasibility and desirability and, if required by the circumstances, works for the satisfactory reclamation of the land are designed and staked out.

Many settlers who realize the benefits of mixed farming are actively interesting themselves in draining small lakes and sloughs, and are constructing works to lower the level of these in order that more hay may be grown and cut. In some instances, control works are installed to hold the water on the land for a short period in the spring for irrigation purposes, after which it is let off so as to permit of the cutting and making of hay. This is the cheapest form of drainage project, necessitating only the lowering of the water-table from one to one and one-half feet below the surface of the land. At a later stage, when the benefits of this partial reclamation have been secured, the settler may, at a slightly increased cost, deepen the ditches and thoroughly reclaim the land so that it may be cultivated for the production of cereals, which requires effective drainage of three to five feet.

The locations of small drainage projects are generally to be found in groups. The development of these groups comes about by the success of a drainage pioneer in a certain district whose methods and example are immediately followed by his neighbours.

During last season forty-nine of such projects were investigated and inspected. In one particular group alone, comprising 11 small projects situated in the New Sarepta district, southeast of Edmonton, 1,400 tons of hay, valued at $15,000, were obtained from reclaimed land formerly underlying valueless shallow lakes and marshes.

During the five years in which drainage investigations have been carried out by the Drainage Division of the Reclamation Service, two hundred and seventy-one investigations and inspections of small schemes have been made. The average cost of reclamation for small projects is $8.90 per acre. There are about 15,000 acres of land under process of being reclaimed by these schemes, of which about 50 per cent has been already permanently reclaimed.

Provincial General Projects

During the past season our engineers inspected six projects of this character—two in Alberta and four in Saskatchewan. The Federal Government in these cases is only interested as regards the removal of the water and, in a few instances, in the disposal of Crown land where a small area of vacant Dominion land is included in the provincial drainage districts. The provinces in accordance with the existing drainage laws are required to obtain the approval of this department before commencing drainage operations.

Since 1919, twenty of these projects have been developed in Saskatchewan and five in Alberta.

Provincial drainage projects are usually situated in the better settled districts where, although the lack of drainage has been generally felt, it has not prevented a very considerable percentage of the land being satisfactorily cultivated. As land values increase, the time arrives when it is economically desirable to reclaim unproductive and waste land in such localities. The settlers then organize under the provisions of the provincial drainage laws, which require that the resident

owners of at least two-thirds of the area of the lands affected by the project shall be in favour of drainage before the drainage district may be erected. Very careful consideration is given by the provinces, to applications for the erection of drainage districts because of the financial obligations, that directly and indirectly are the result of drainage, especially when it means the opening up of outlying districts. In such cases roads, highways, drains, telephones and school systems, etc., have to be extended to serve the newer sections. The problem, however, is largely one of economics, which is reflected by the conditions obtaining generally in the country as a whole.

Large Projects Investigated by the Dominion Government

No new investigations were commenced this season, the field work being confined entirely to completing the investigations unfinished from the previous season.

CARROT RIVER TRIANGLE DRAINAGE PROJECT

The district known as the Carrot River Triangle comprises an area of about 1,086 square miles and is situated in the triangle formed by the Saskatchewan and Carrot rivers and the Sipanok channel—an overflow channel of the Saskatchewan river. There is an additional area of 350 square miles adjoining this district on the east, known as the Pasquia extension of the large swamp, which has also been investigated by engineers of the department.

Several partial investigations and surveys have been made in past years with a view to ascertaining the feasibility of reclaiming this land for agricultural purposes, but owing to the magnitude of the project, the inadequacy of the staff and the short time spent on the surveys, these merely indicated that drainage appeared to be feasible and that the land when drained would be suitable for farming. One of the greatest difficulties in the investigation was the practical impossibility of penetrating to and surveying the greater portion of the interior during the open season.

When this work was undertaken by the Reclamation Service in 1921, two survey parties were detailed to survey and investigate the river portions along the banks of the Saskatchewan and Carrot rivers during the summer and to establish bench-marks and base lines. These parties continued work during the winter months on a part of the interior. Surveys and investigations of this nature were carried out in 1922 and were completed this season.

Generally speaking the method of reclamation will consist in the construction of levees along the banks of the Saskatchewan and Carrot rivers to keep out the flood waters, and of a system of interior drainage ditches to carry the run-off to sumps, and thence to be pumped over the dykes into these two streams.

Until the several plans of reclamation upon which the engineers are now engaged are considered and compared, the cost of the projects or units of the project can only be roughly estimated. Two schemes of reclamation are being considered:—

(*a*) The reclamation of the whole area.

(*b*) The reclamation only of the eastern or Manitoba end of the triangle and of the Pasquia extension.

Under the former, the triangle would be divided into five drainage units, each with its protective levees and system of ditches conveying the drainage water to the most convenient point to be pumped into either the Saskatchewan or Carrot rivers. It is roughly estimated that this scheme would involve an expenditure of $6,100,000 to reclaim some 700,000 acres, or an average cost

of \$8.70 per acre. The later scheme contemplates the reclamation only of the eastern part of the district by cutting off this area from the remainder of the tract by a levee extending from the Carrot to the Saskatchewan river. It is roughly esimated that this scheme would cost \$2,112,000 to reclaim 164,000 acres, or an average of \$12.90 per acre. When it is considered that the reclamation of timber and brush lands involves a cost of from \$20 to \$40 per acre for clearing alone the above cost of drainage is comparatively very small.

WATERHEN LAKE DRAINAGE DISTRICT

In the preceding reports a full account of the development of the Waterhen Lake Drainage project to date was given.

During the past season the right-of-way of the canals located on privately owned land was fenced under contract by Mr. W. A. Weatherby, Kinistino, Saskatchewan, who carried out the work, consisting of 3,400 rods of 3 strands of barb wire at a price of \$0.97 per linear rod. The total cost of fencing amounted to \$3,470.

By an arrangement with the Department of Highways, Regina, Saskatchewan, a provincial bridge crew erected four standard wooden highway bridges and one wooden hold-up gate in 1922 and 1923. These structures were built on plans designed and furnished by and at a cost of \$12,700 to the department.

Four cast-iron culverts, 36 inches in diameter, were placed in the levees on the lake canal during 1923. These culverts were fitted with metal-flap gates to control the flow over the reclaimed lake bed during flood stages of the Carrot river. Concrete end walls were constructed at the lower end of each culvert as a protection against erosion and to support the gates.

About 4,770 rods of surface ditching were constructed in the reclaimed bed of Waterhen lake in 1923. The ditching was done by a plough, cutting a ditch of 6 inches bottom width, 4 feet top width, and 3 feet in depth. The plough is pulled by a capstan operated by horse power. The cost of this work reached \$4,706, or an average cost per rod of 98.8 cents.

As it is necessary for the department to purchase the land required for the right of way for the drainage canals on privately owned land, surveys were carried out by a Saskatchewan land surveyor, and plans are now being registered in the Land Titles office at Prince Albert, Saskatchewan.

The water was let off from the lake and marsh in July, 1922, and since that time the land affected has dried out to a very considerable extent.

The water table in both the marsh and lake has been steadily lowering since the completion of the main drainage works. It was very noticeable during the season of 1923, that the heavy reed growth covering the greater part of the marsh and the shores and west end of the lake before drainage were gradually dwindling and giving place to good commercial wild grasses. More wild hay has been available since the completion of the drainage works than ever before. Grass fires in the spring, swept over large areas and cleared off much of the dead grass at the roots, providing an excellent crop in 1923.

An experimental plot was operated last season by the department on the reclaimed land to ascertain what cereals, grasses, roots, etc. were best adapted for this particular class of soil. The University of Saskatchewan kindly co-operated in the experiments and much valuable data were obtained. Oats, barley, timothy, brome grass, western rye grass and red top showed excellent results.

Before disposing of the reclaimed vacant Dominion land by auction sale, the department has decided to lease it for a number of years at a nominal rental, during which the agricultural value of the land will be definitely

established. A better price for the land will be obtainable in this manner, than if it were now placed on the market so soon after reclamation.

The total money appropriated by Parliament for the construction of the Waterhen Lake drainage district was $173,000. When a few outstanding accounts have been adjusted the actual cost of construction will not exceed $170,000, which is well within the limit of cost provided for in the estimates.

SUMMARY

Since 1919 thirty-six large projects have been investigated by the department. Only in one case—Waterhen Lake Drainage project—has construction been undertaken by the department. The total area involved in these investigations reaches the huge total of 1,560,000 acres.

CLASSIFIED LIST OF PUBLICATIONS

WATER POWER

The Reports pertaining to Water Power, published by the Dominion Water Power and Reclamation Service, with the exception of the Annual Reports, have been called Water Resources Papers, and have been numbered 1, 2, etc.

Annual Reports previous to 1913 are included with the Annual Report of the Department of the Interior, and can be secured from the secretary of the department.

Annual Reports for the fiscal years ending March 31, from 1913 to 1924, are available for distribution. That for 1924 is the first report combining the activities of the Water Power and Reclamation divisions of the Service.

REPORTS OF SPECIAL OR GENERAL INTEREST

Water Resources Paper No. 2.—Report on Bow River Power and Storage Investigations (Bow river west of Calgary), by M. C. Hendry, chief engineer in charge of surveys. This is a complete study of the Bow river west of Calgary. It deals with meteorological conditions and their effect on run-off and ice formation. Existing and possible power and storage developments, together with maps and plans are appended complete. Published 1914.

Water Resources Paper No. 3.—Report on Power and Storage Investigations, Winnipeg River, by J. T. Johnston, chief hydraulic engineer, Dominion Water Power Branch. A complete study based on field surveys and office computations of the Winnipeg River basin; deals fully with history, international considerations, topography, climate, storage possibilities; describes existing and gives preliminary designs and estimates for possible power developments; discusses other sources of power and the power market. Maps, plans and all relevant data are appended. Published 1915.

Water Resources Paper No. 5.—Preliminary Report on the Pasquia Reclamation Project, by T. H. Dunn, chief engineer in charge of Reclamation Survey. This is a progress report of investigations carried out to determine the possibility of lowering the level of Cedar lake and its effect in a general scheme for reclaiming the low-lying lands contiguous to the Saskatchewan river in the Pasquia region. Published 1914. Out of print.

Water Resources Paper No. 6.—Report on cost of various sources of power for pumping in connection with the South Saskatchewan Water Supply Diversion Project, by H. E. M. Kensit. It deals with the problem of power for pumping water from the South Saskatchewan river for the supply of cities and towns in the central portion of south Saskatchewan. Published 1914. Out of print.

Water Resources Paper No. 7.—Report on the Manitoba Water Powers, by D. L. McLean, S. S. Scovil and J. T. Johnston, compiled for the Manitoba Public Utilities Commission. A general survey of the water-power situation in Manitoba, with all available general information and hydrometric data published to date in condensed form concerning the rivers in Manitoba. Published 1914.

Water Resources Paper No. 10.—General Guide for Compilation of Water Power Reports of Dominion Water Power Branch, prepared for the guidance of field engineers of the Dominion Water Power Branch, by J. T. Johnston, chief hydraulic engineer. Published 1915. Limited edition.

Water Resources Paper No. 11.—Second Report on the Pasquia Reclamation Project by T. H. Dunn, chief engineer in charge of Reclamation Survey. This is a continuation Report based on further investigations as outlined under Water Resources Paper No. 5. Published 1915. Out of print.

Water Resources Paper No. 12.—Report on Small Water Powers in Western Canada, and discussion on sources of power for the Farm, by A. M. Beale. Part I is a brief description of certain small western water-power developments. Part II gives an analysis of requirements and cost data for the farm power supply. Published 1915. Out of print.

Water Resources Paper No. 13.—Report on the Coquitlam-Buntzen Hydro-Electric Development. A complete discription of the project and of the details of construction, with plans, diagrams and illustrations, by G. R. G. Conway, chief engineer of the British Columbia Electric Railway Company, Limited. Published 1915.

CLASSIFIED LIST OF PUBLICATIONS—Continued

Water Resources Paper No. 16.—Water Powers of Canada. A series of five pamphlets in one volume covering the water-power situation in Canada, prepared for distribution at the Panama Pacific Exposition, San Francisco, 1915, by G. R. G. Conway, consulting engineer, Toronto; Percival H. Mitchell, consulting engineer, Toronto; H. G. Acres, hydraulic engineer, Hydro-Electric Power Commission, Ontario; F. T. Kaelin, assistant chief engineer, Shawinigan Water and Power Co., Montreal; K. H. Smith, engineer, Nova Scotia Water Power Commission, Halifax, N.S., Published 1916. Out of print.

Water Resources Paper No. 17.—Canadian Hydraulic Power Development and Electric Power in Canadian Industry, by Charles H. Mitchell, consulting engineer to Dominion Water Power Branch. Part I deals with progress of ultilization, features in design, construction and operation specially applicable to Canada. Description of certain typical Canadian water-power developments. Part II analyses the uses, growth and future of electrical power in Canadian industry. Published 1916. Out of print.

Water Resources Paper No. 20.— Report on the Interests Dependent on Winnipeg River Power, with Special Reference to the Capital Invested and the Labour Employed, by H. E. M. Kensit. A detailed study of the industrial growth and future power requirements of the district tributary to the Winnipeg River power sites. Published 1917. Out of print.

Water Resources Paper No. 27.—Directory of Central Electric Stations in Canada to January 1, 1919, compiled by J. T. Johnston, assistant director, Dominion Water Power Branch. Comprises an analysis of the central electric census statistics and a directory of the stations. Published 1919. Out of print.

Water Resources Paper No. 32.—Water Resources Index Inventory, by J. T. Johnston. Description of the Index Inventory System for recording and collating the water resources data of the Dominion. Published 1922. Out of print.

Water Resources Paper No. 33.—Directory of Central Electric Stations in Canada, to November 1, 1922. Comprises an analysis of the central electric station statistics and a directory of the stations. Published 1923. Price, 50 cents.

SURFACE WATER SUPPLY REPORTS

ATLANTIC DRAINAGE SOUTH OF ST. LAWRENCE RIVER INCLUDING NOVA SCOTIA, NEW BRUNSWICK, PRINCE EDWARD ISLAND, AND SOUTHEASTERN QUEBEC.

Water Resources Papers Nos. 29 and 37.—Surface water supply of Canada. Report on hydrometric surveys covering the Atlantic drainage south of the St. Lawrence river, including Nova Scotia, New Brunswick, and Prince Edward Island and southeastern Quebec, for the climatic years ending September 30, 1919 and 1920, and September 30, 1920 and 1921, by K. H. Smith, district chief engineer.

ST. LAWRENCE AND SOUTHERN HUDSON BAY DRAINAGE IN QUEBEC

Water Resources Paper No. 41.—Surface water supply of Canada. Report on hydrometric surveys covering the St. Lawrence and southern Hudson Bay drainage in Quebec for the climatic year ending September 30, 1923, by Leo G. Denis, district chief engineer. In course of preparation.

ST. LAWRENCE AND SOUTHERN HUDSON BAY DRAINAGE IN ONTARIO

Water Resources Papers Nos. 28, 34, 38 and 42.—Surface water supply of Canada. Reports on hydrometric surveys covering the St. Lawrence and southern Hudson Bay drainage in Ontario for the climatic years ending September 30, 1920, 1921, 1922 and 1923, by S. S. Scovil, district chief engineer.

ARCTIC AND WESTERN HUDSON BAY DRAINAGE (AND MISSISSIPPI DRAINAGE IN CANADA) IN ALBERTA, SASKATCHEWAN, MANITOBA, EXTREME WESTERN ONTARIO, AND NORTHWEST TERRITORIES

Water Resources Papers Nos. 4, 19, 22, 24 and 26.—Surface water supply of Canada Reports on hydrometric surveys in Manitoba, from January 1, 1912, to September 30, 1919, by M. C. Hendry and C. H. Attwood, chief engineers. No. 4 contains a gazetteer of lakes and streams in Manitoba.

CLASSIFIED LIST OF PUBLICATIONS—Concluded

Water Resources Papers Nos. 31, 36, 40 and 44.—Surface water supply of Canada. Reports on hydrometric surveys covering the Arctic and western Hudson Bay drainage (and Mississippi drainage in Canada) in Alberta, Saskatchewan, Manitoba, extreme western Ontario and the Northwest Territories, for the climatic years ending September 30, 1920, 1921, 1922, and 1923, by C. H. Attwood and A. L. Ford, district chief engineers. Previous to 1919-1920 the surveys in Alberta and Saskatchewan were carried on and the results published by the Reclamation Service, Department of the Interior.

PACIFIC DRAINAGE IN BRITISH COLUMBIA AND THE YUKON TERRITORY

Water Resources Papers Nos. 1, 8, 14, 18, 21, 23, 25, 30, 35, 39 and 43.—Surface water supply of Canada. Reports on hydrometric surveys covering the Pacific drainage in British Columbia and the Yukon Territory from May, 1911, to September 30, 1923. No. 1 is by P. A. Carson, chief engineer, the others by R. G. Swan, district chief engineer. No. 1 contains an outline of the history of the Railway Belt with special reference to its administrative, legal and physical problems in regard to water, and a gazetteer of the lakes and streams in British Columbia.

RECLAMATION

Drainage Regulations.

Irrigation Regulations.

Annual Irrigation Reports—1912 to 1915.

Irrigation Surveys and Inspections Reports—1915. (1915-16). (1916-17). (1917-18). (1918-19).

Annual Report of the Reclamation Service—(1919-20), (1920-21). (1921-22). (1922-23).

Annual Report of the Water Power and Reclamation Service (1923-24).

Western Canada Irrigation Association Reports—(1st to 11th Convention).

International Irrigation Congress Report (1914).

Bulletin No. 1—Irrigation in Alberta and Saskatchewan.
(Consisting of a Synopsis of the Irrigation Act and its Administration.)

Bulletin No. 2—Alfalfa Culture.

Bulletin No. 3—Climatic and Soil Conditions, C.P.R. Irrigation Block.

Bulletin No. 4—Duty of Water Experiments and Farm Demonstration Work.

Bulletin No. 5—Farm Water Supply.

Bulletin No. 6—Irrigation Practice and Water Requirements for Crops in Alberta.

Pamphlets:

Address by Mr. S. G. Porter—"Practical Operation of Irrigation Works."—Extract from W.C.I.A. Report, 1914.

Address by Dr. Rutherford—"Inter-dependence of Farm and City."—Extract from W.C.I.A. Report, 1914.

Address by Mr. Don. H. Bark—"The Actual Problem that Confronts the Irrigator."—Extract from W.C.I.A. Report, 1914.

Address by Mr. Don. H. Bark—" Practical Irrigation Hints for Alberta."—Extract from W.C.I.A. Report, 1915.

Address by Mr. Don. H. Bark—"Alfalfa Growing."—Extract from W.C.I.A. Report, 1915.

"'Practical Information for Beginners in Irrigation" (by W. H. Snelson, A.M.E.I.C.).

Water Resources Papers, and Irrigation and Drainage Reports, as listed at the end of this report are issued gratis, with the exception of Water Resources Paper No. 33, for which a charge of 50 cents is made. These can be had on application to the Director of Dominion Water Power and Reclamation Service, Department of the Interior, Ottawa.

DEPARTMENT OF THE INTERIOR, CANADA

HON. CHARLES STEWART, Minister; W. W. CORY, C.M.G., Deputy Minister

DOMINION WATER POWER AND RECLAMATION SERVICE

J. T. JOHNSTON, C.E., Director

ANNUAL REPORT

1924-25

OTTAWA
F. A. ACLAND
PRINTER TO THE KING'S MOST EXCELLENT MAJESTY
1926

DEPARTMENT OF THE INTERIOR, CANADA
HON. CHARLES STEWART, Minister; W. W. CORY, C.M.G., Deputy Minister

DOMINION WATER POWER AND RECLAMATION SERVICE
J. T. JOHNSTON, C.E., Director

ANNUAL REPORT

OF THE

DOMINION WATER POWER

AND

RECLAMATION SERVICE

FOR THE

Fiscal Year Ending March 31, 1925

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WATER POWER AND RECLAMATION

INTRODUCTORY

The amalgamation of the Dominion Water Power Branch and the Reclamation Service was referred to in the last Annual Report. During the past fiscal year the adjustment of all the details incidental to this amalgamation was completed and all necessary reorganization effected.

ORGANIZATION

Water Power.—The water-power activities are both administrative and investigatory. The proprietary interest of the Dominion in the water resources of Alberta, Saskatchewan and Manitoba, of the Northwest and Yukon Territories and of the Railway Belt in British Columbia gives rise to the necessity of administering these resources in accordance with the Dominion Water Power Act and the Regulations thereunder, and places upon this service the responsibility of securing such fundamental engineering and economic data as will enable it properly to control the development, distribution and sale of hydro-electric energy.

Throughout the rest of Canada the water-powers are vested in the provinces and investigatory work is carried on in co-operation with the respective provincial authorities charged with the administration of these resources. The service also co-operates extensively with federal departments and commissions other than the Department of the Interior, making the services of its field engineering staff available to these organizations when, in the interests of general economy and efficiency, it is desirable to do so.

The co-operative water-power and hydrometric survey work is undertaken through district officers, each in charge of a district chief engineer, located as follows: British Columbia, at 119 Pender street West, Vancouver; Alberta and Saskatchewan, at Southam Chambers, Calgary; Manitoba, at 231 Chambers of Commerce Block, Winnipeg; Ontario, the local organization has headquarters at the Ottawa office of the service; Quebec, at 201 Inspector street, Montreal; the Maritime Provinces, at 193 Hollis street, Halifax. In every case the district offices are operated in the closest co-operation with the provincial officers engaged in the administration or use of water or water-power.

In the Yukon and Northwest Territories the water-power resources are administered from Ottawa and, in the case of the Yukon, through the Gold Commissioner at Dawson. Investigatory work in the Yukon is handled through the British Columbia organization and in the balance of the Territories as the exigencies of the situation demand.

The water-power field organization is based upon and built up around the Dominion Hydrometric Survey staff, through which systematic and continuous stream-measurement studies are carried on throughout the Dominion. The data secured by the hydrometric staff and through the co-operative efforts of the various provincial and other organizations are collated, analysed and standardized at the head office of the service at Ottawa, with the result that there is already available in Ottawa both general and detailed information concerning the run-off and power possibilities of the more important power rivers throughout Canada. These data are constantly being revised as new or later information is received and are promptly available for reference to all interested in the utilization of the water-powers of the Dominion.

Irrigation and Drainage.—The Federal Irrigation Act, the Federal Reclamation Act, and Regulations, provide the bases of irrigation and drainage activities.

Under the provisions of the Irrigation Act the ownership and administration of all surplus water supply in the provinces of Alberta, Saskatchewan, and northern Manitoba are vested in the Crown. All licenses for the use of water are conditional upon continuous beneficial use. A local organization, in charge of the Commissioner of Irrigation, Calgary, is responsible for the field administration.

The Reclamation Act and the Regulations are administered along similar lines All field investigations are carried out by the local office upon instructions from Ottawa. Any questions of drainage affecting departmental interests in the provinces of Manitoba and British Columbia are dealt with through the agency of the district chief engineers of this service in those provinces. Close co-operation is maintained with the provincial drainage departments at all times.

PUBLICATIONS

A list of the annual reports, water resources papers and reclamation reports published to date will be found at the end of this report, and copies of those which are still in print will be sent on application to those interested, free of charge, except in the case of the Directory of Central Electric Stations, for which a charge of 50 cents is made.

During the past year the Annual Report of the Dominion Water Power and Reclamation Service for the fiscal year 1923-24 and Water Resources Papers Nos. 40, 42 and 43 were published. Water Resources Papers Nos. 41 and 44 are now in press. Bulletins were published dealing with: Hydro-Electric Progress in Canada during 1924; and the Water Power Resources of Canada, February 1, 1925.

PART I

WATER POWER

(*a*) HEAD OFFICE

The First World Power Conference

During the month of July, 1924, there was held in London, England, the First World Power Conference, the purpose of which was to consider from a world standpoint the sources of power, the methods of administration and development and all the varied aspects of power application, both nationally and internationally.

The scheme for holding this conference at Wembley during the course of the British Empire Exhibition had been evolved by the British Electrical and Allied Manufacturer's Association and was organized by a strong British committee. Invitations to attend were sent to countries throughout the world and resulted in forty-four nations being represented by delegates of outstanding reputation in the realm of power matters, and in more than four hundred papers on the various phases of power and power resources being presented.

Canadian participation in the conference was organized by a committee representative of the power interests throughout the whole Dominion, under the honorary chairmanship of the Honourable the Minister of the Interior and Mines and the chairmanship of the Deputy Minister of Mines. The Director of Water Power took active charge of organizing the Canadian effort and headed the delegation which attended the conference in England. Papers were prepared by recognized authorities covering the most outstanding features of the power situation in the Dominion and the Canadian delegates took a prominent part in all the discussions of the conference.

Subsequent to the conference three tours were carried out; one through the great industrial centres of Great Britain, a second to the water-powers of Norway and Sweden and the third to visit the power plants of Switzerland, France and Italy. Canadians were represented on all these tours and gained much valuable information concerning European practice in power matters.

The results of the conference were far-reaching towards establishing an inventory of the world's resources in power, and enabling the representatives from the many countries in attendance to meet and exchange experiences in the methods of administration, development and application of power resources. The conference also served to demonstrate that Canada is among the leading countries of the world with respect to power resources and the manner in which they are being administered and developed.

Lake of the Woods Control Board

The regulation of the level and outflow of Lake of the Woods has, as in previous years, been the responsibility of the Lake of the Woods Control Board. This involves, among other things, the continuous collection of hydrological data relating to the watershed. In the securing of these data, the board was indebted to the Department of Public Works for run-off records on Rainy and Namakan lakes, and to the Dominion Meteorological Service for precipitation records at numerous stations throughout the watershed. As a consequence of very light precipitation throughout the year, lake level fell from elevation 1057.6 on March 31, 1924, to elevation 1055.2 on March 1, 1925, the latter elevation being the lowest in the past thirty-three years of record.

Low levels and outflow gave rise to very serious conditions, both adjoining the lake and at the power-houses on the Winnipeg river, and it became imperative that immediate action be taken to provide proper control facilities at the lake outlets. To this end an agreement was entered into with the Keewatin Power Company, the owner of the Norman dam in the western outlet of the lake, for the enlargement of the western outlet so as to provide a total discharge capacity from the lake of 47,000 sec.-ft. and for the reconstruction of the Norman dam in such manner as would make it a suitable and efficient control structure, both measures being in entire conformity with the recommendations made by the International Joint Commission in their final report on Lake of the Woods matters in 1917.

Work at the western outlet and Norman dam has been under way since December 12, 1924, completion being scheduled for December, 1925. Upon provision of these measures, proper and efficient control of levels and outflow will be possible, and as a consequence, the domestic water supply and power requirements of Winnipeg, Kenora and surrounding districts will be protected.

Water-Power Regulations and Legal Research

Final licenses covering two of the major power developments in the Prairie Provinces are being prepared to take the place of the original agreements under which the developments were constructed and are now being operated.

The systematic study of past and present Dominion and provincial legislation in Canada dealing with the uses of water, more particularly for power purposes, referred to in last year's report, has been continued. In this connection a synopsis of the existing water-power legislation throughout Canada was prepared for presentation to the first World Power Conference held in London, England, during July, 1924. A number of reports and memoranda have been prepared on this subject in response to specific inquiries, including a comprehensive list of acts relating to the uses of water now in force in each province, prepared at the request of the Consul-General for Poland.

The Advisory and Technical Committee for Communications and Transit, one of the subsidiary organizations of the League of Nations, the formation of which was provided for in the Covenant of the League, has in recent years been active in holding international conferences. Representatives of all members of the League have been invited to consider and, if deemed advisable, adopt various statutes and conventions or treaties dealing with some of the many important subjects within the purview of that organization.

Two of these conventions, relating to the transmission in transit of electric power and to the development of hydraulic power affecting more than one state, adopted by a general conference at Geneva, December 9, 1923, are of particular interest to this department.

British Columbia Administration

The examination of water records issued by the province of British Columbia authorizing the use of waters within the Railway Belt, under the provincial Water Act, and those appurtenant to lands within the Railway Belt, has been continued; and the granting of necessary rights on Dominion lands, required for the exercise of these privileges, is proceeding satisfactorily, with the cordial co-operation of the provincial Comptroller of Water Rights.

The project of the Burrard Power Company, a subsidiary of the British Columbia Electric Railway Company, to develop additional power on Stave lake and river by erecting a dam at the foot of Alouette lake and diverting the waters of that lake by means of a tunnel into Stave lake, is now under construction. The Dominion lands required for these purposes have been

secured to the company, and in the design of the dam now being erected at the foot of Alouette lake, due provision has been made for the protection of the rights of the Crown timber licensees surrounding the lake.

In co-operation with the Department of Indian Affairs, further progress was made towards the settlement of Indian claims for water rights, and, as in previous years, a considerable number of investigations were made throughout the province by the local engineering staff of this service on behalf of that department, and structural improvements carried out on the Indian reserves.

Details of this co-operative work will be found in the report of the district chief engineer for British Columbia.

Co-operation with Indian Department in Ontario

The Department of Indian Affairs has recently built a residential school for Indians near McIntosh, Ont., close to which is a small power-site well adapted for the use of the school. At the request of the Indian Department, the district chief engineer of this service at Winnipeg prepared plans for the development and use of this power, also for domestic water supply and sewage disposal systems. These projects have been approved, and construction was begun on the sewage system last October and on the power site in November. About 30 h.-p. will be developed and this will be used for electric lighting, pumping for domestic water supply and fire protection, and power for a machine shop, carpenter shop and laundry. The work was temporarily closed down during the extreme winter months.

Water Resources Index Inventory

For the purpose of recording and collating the water resources data of the Dominion an index inventory system was devised some years ago by the service and has since been found most advantageous in its application. The system has been described in some detail in the Annual Report for 1916-17 and in the combined report for the years 1917-18-19.

This system has been applied broadly to the activities of the organization and has been found particularly useful in its application to the complete census of developed water-power, the analysis of central electric station activities, undeveloped water-power resources, stream measurement activities and storage investigations.

After a number of years of sustained effort in the collection and analysis of water resources data throughout the Dominion there has now been compiled in the index inventory a very large amount of information in such standardized and usable form that it is available for almost any purpose. The data so compiled are being continually brought up to date and the work is greatly facilitated by the co-operation secured from such provincial organizations as the Hydro-Electric Power Commission of Ontario, the Quebec Streams Commission, the British Columbia Water Rights Branch, the Nova Scotia Power Commission, and the New Brunswick Electric Power Commission.

Water-power Resources of Canada

The steady, consistent growth of water-power development in Canada which was again evidenced during the year just closed emphasizes the importance of making an annual inventory of our water-power resources in order that accurate information as to the availability and use of this great national asset may be available.

With the installation during the year 1924 of new wheels aggregating over 300,000 h.-p. there is now installed for all purposes a total of 3,569,275 h.-p. and by the completion of plants at present under construction this figure will be

increased by over 600,000 h.-p. before the end of 1925. Outstanding features of the developments under way or recently completed are their magnitude, the fact that they are not confined to any particular section of the country but extend from coast to coast, and the large proportion of the power being installed which will be available for public use through the medium of central electric station organizations.

Complete data regarding Canada's great water-power resources are not yet available but a great quantity of reasonably accurate as well as considerable specific data have been collected and are available from the records of this service. All existing stream-flow and power data available from federal, provincial and private sources have been systematically collated, reanalyzed and co-ordinated with a view to preparing revised estimates of available power based on uniform methods of computation and arrangement.

BASIS OF COMPUTATION

The figures available for water-power listed in table 1 are based upon rapids, falls and power sites of which the actual existent drop or the head possible of concentration is definitely established or at least well authenticated. Many rapids and falls of greater or less power capacity are scattered on rivers and streams from coast to coast which are not as yet recorded, and which will only become available for tabulation as more detailed survey work is undertaken and completed. This is particularly true in the relatively unexplored northern districts. Nor is any consideration given to the power concentrations which are feasible on rivers and streams of gradual gradient, where economic heads may be created by the construction of power dams, excepting only at such points as definite studies have been carried out and the results made matters of record.

In brief, the figures hereunder are based on definite rapids, falls and power sites, and may be said to represent the *minimum water-power possibilities of the Dominion.*

The power estimates have been calculated on the basis of 24-hour power at 80 per cent efficiency for conditions of " Ordinary Minimum Flow " and " Ordinary Six Months Flow". The " Ordinary Minimum Flow " is based on the averages of the flows for the two lowest periods of seven consecutive days in each year, over the period for which records are available. The " Ordinary Six Months Flow " is based upon the continuous power indicated by the flow of the stream for six months in the year. The actual method to determine this flow is to arrange the months of each year according to the day of the lowest flow in each. The lowest of the six high months is taken as the basic month. The average flow of the lowest seven consecutive days in this month determines the maximum for that year. The average of such maximum figures for all years in the period for which data are available is the estimated maximum used in the calculation.

This estimated maximum development is based upon the assumption that it is good commercial practice to develop wheel installation up to an amount, the continued operation of which can be assured during six months of the year, on the assumption that the deficiency in power during the remainder of the year can be profitably provided from storage or by the installation of fuel power plants as auxiliaries. The correctness or otherwise of this assumption for any particular site can only be definitely settled by careful consideration of all circumstances and conditions pertinent to its development. The method, however, enables the service to make a fairly satisfactory over-all estimate of the maximum hydraulic power available as distinctive from the estimated ordinary minimum power available.

AVAILABLE AND DEVELOPED TOTALS

The known available water-power in Canada, from all sources and within the limitations outlined, is 18,255,000 h.-p. for conditions of ordinary minimum flow and 32,076,000 h.-p. under a flow estimated for maximum development, i.e. dependable for at least six months of the year.

It is believed that these are conservative estimates since an analysis of the water-power plants scattered from coast to coast concerning which complete data are available as to turbine installation and satisfactory information as to stream-flow, gives an average machine installation 30 per cent greater than the six-month flow maximum power. Applying this, the figures quoted above, therefore, indicate that the present *recorded water-power resources* of the Dominion will permit of a turbine installation of 41,700,000 h.-p.

The total installation to date in water-wheels and turbines throughout the Dominion is 3,569,275 h.-p. In other words the present turbine installation represents only *8½ per cent* of the recorded water-power resources.

CURRENT PROGRESS IN DEVELOPMENT

A review by this service indicates that in the sphere of hydro-electric and water-power development the year 1924 was one of pronounced activity throughout the Dominion. Not only was a substantial increase recorded in the total installation but many large projects were advanced to such a state that a further extensive increase will be effected during the year 1925. More than 300,000 h.-p. were added during the year bringing the total installation in the Dominion to a figure of 3,569,275 h.-p. while with the installations nearing completion this figure will be increased by more than 600,000 h.-p. during 1925.

Special interest attaches to the activities of the present time when compared with those of a few years ago, in the magnitude of individual developments and the speed achieved in their construction. Where a few years ago blocks of ten to twenty thousand horse-power were thrown upon the market, now plants in excess of one hundred thousand horse-power are brought into operation in a single year. Modern construction methods have also advanced to meet the demand for speedy development so that it is not uncommon for plants of large magnitude to be completed within the space of twelve months.

Practically every province is represented in the year's activities, the details of which are briefly recorded in the paragraphs following. Among these the most outstanding are the activities of the British Columbia Electric Railway Company, and the West Kootenay Power and Light Company in British Columbia; the city of Winnipeg in Manitoba; the Ontario Hydro-Electric Power Commission, the Hollinger Consolidated Gold Mines, the Canadian Niagara Power Company, and the Backus-Brooks Company in Ontario; the St. Maurice Power Company, the Montreal Light, Heat and Power Consolidated, the Northern Canada Power Company, the Ottawa River Power Company, the Southern Canada Power Company, and the Duke-Price Power Company in Quebec; and the Nova Scotia Power Commission in Nova Scotia.

British Columbia.—While no new installation may be credited to British Columbia's total during 1924, activities of prime importance were carried forward during the year, the results of which will be effective in considerably increasing the generating capacities of several stations during 1925.

The British Columbia Electric Railway Company continued extensive operations in the Stave Lake region. Following the raising of the Stave lake dams which provided for a 22-foot increase in storage draft on the lake the company commenced the installation of a fifth unit of 15,000 h.-p. in the power station. The four existing units are also being rewound to increase their rated capacity. When this work is completed in 1925 the Stave Falls plant will have a total rated capacity of about 85,000 h.-p.

Work was also started by the same company on the diversion of the waters of Alouette lake by means of a tunnel to a power-house located on Stave lake about 10½ miles above the Stave Falls plant. The Alouette plant will have a capacity of 12,500 h.-p. and its completion is anticipated in 1926.

On Vancouver island the company duplicated its transmission line between the Jordan River plant and Victoria. Plans are also being prepared for increasing the storage capacity of the Jordan River dam during 1925.

The West Kootenay Power and Light Company Limited, entirely demolished its plant No. 1 at Lower Bonnington falls on the Kootenay river and commenced the construction of a new plant which will have an ultimate capacity of 60,000 h.-p. The initial installation of 40,000 h.-p. is expected to be in operation during 1925.

The Powell River Company added to the height of its dam on Powell river thereby increasing the storage capacity by 630 square mile feet. Future plans of the company include the installation of some 20,000 h.-p. additional capacity in the power plant connected with its newsprint mills.

The East Kootenay Power Company completed the works in connection with its 15,000-h.p. development on the Elk river which together with a plant on the Bull river serves with power a considerable area in southeastern British Columbia.

Among investigations carried out during the year by a number of organizations interested in the development of power, such rivers as the Stamp, Cheakamus, Bridge and Columbia were considered.

Alberta.—On the Cascade river near Banff the Dominion Parks Branch of the Department of the Interior completed and placed in operation a hydro-electric development of 960 h.-p. together with a transmission line connecting the plant to Banff where the power is used for lighting and general power purposes.

The Calgary Power Company completed a new transmission line between Calgary and its plants on the Bow river thereby duplicating the existing line.

Manitoba.—The city of Winnipeg has ordered equipment which will provide three additional units of 7,300-h.p. capacity each, in its Pointe du Bois power station on the Winnipeg river. The first of these units was in place at the end of January.

In connection with the city's hydro-electric enterprise a steam stand-by plant in combination with a central steam heating and distributing system was completed and put in operation early in October at a cost of $1,250,000. The stand-by plant which has a capacity of 11,000 kw. is designed to take care of interruptions which may occur in the supply of hydro-electric power from the Winnipeg river while its boilers in conjunction with two 7,500 kv.a. electric steam generators using surplus or off-peak hydro-power provide steam for the heating of a considerable section of the central business portion of the city.

Ontario.—A substantial increase amounting to some 132,000 h.-p. was made during the year to the total water-power installation in the province. While the greater part of this was accounted for in addition of units to existing stations there were also several entirely new developments. These activities embraced all parts of the province, the most important being in the territory served by the Hydro-Electric Power Commission, in the mining territory of northern Ontario and in the extreme western part at Kenora.

The Ontario Hydro-Electric Power Commission carried on a vigorous program of construction throughout the territory which it serves. At the head of the lakes the capacity of the Nipigon station was increased by the addition of two 12,500 h.-p. units bringing the total to 50,000 h.-p. Two further units of similar capacity which are being added in 1925 will complete the designed capacity of the Nipigon station. In connection with the Nipigon development it

is of interest to mention a field investigation made by the commission during 1924 with respect to diverting waters from the upper Albany river basin to lake Nipigon.

On the Niagara river at the Queenston station the commission brought into operation two more 55,000-h.p. units, numbers six and seven. The eighth and ninth units of similar capacity will, it is expected, be installed during 1925 and the final designed capacity of ten units totalling 550,000 be achieved in 1926.

In the Georgian Bay system a second pipe line was completed at the Eugenia Falls development thereby increasing the capacity of the plant by 2,000 h.-p. The South Falls station on the south branch of the Muskoka river is being remodelled. Two units of 2,200 h.-p. each are being installed, one of these replacing an old unit of 700 h.-p. On the same river at Hanna chute a short distance above South Falls the commission plans the construction of a new 1,800-h.p. development during 1925.

The Bingham Chute plant of 1,200-h.p. capacity was completed and placed in operation early in the year, the power being used in the Nipissing system supplying North Bay and vicinity.

In the Central Ontario system the 6,600-h.p. development at Dam 8 on the Trent river was completed and brought into operation while the 4,800-h.p. development at Dam 9 on the same river will be completed shortly. These stations are of special interest inasmuch as they are both being operated by remote supervisory control from the Ranney Falls station a few miles distant.

In addition to its construction program the commission has been active in investigating new sources of power, studies having been carried on at various points, notably on the St. Lawrence, Ottawa, Muskoka, and Severn rivers.

Apart from the work of the commission numerous activities were proceeded with by other power organizations.

At Niagara Falls the Canadian Niagara Power Company added a new unit of 12,500-h.p. capacity to its hydro-electric station, thereby bringing the total capacity to 121,500 h.-p.

In the mining district of northern Ontario a particularly active program of construction was carried out and new installations brought into operation which should overcome the power shortage that has existed for the past few years. For the Porcupine Gold field two developments were completed and brought into operation, the first by the Northern Canada Power Company on the Quinze river in Quebec, which is referred to more specifically under the Quebec activities, and the second by the Hollinger Consolidated Gold Mines, Limited, at Island Falls on the Abitibi river, where 24,000 h.-p. was installed. For the silver mining area the Northern Ontario Power Company completed the alterations to the Matabitchuan plant, increasing the capacity to 13,200 h.-p. Also in the Gowganda district the South Bay Power Company is engaged in increasing the capacity of its plant and storage works. In the Sudbury nickel district the Lorne Power Company added a new unit of 2,750 h.-p. to its Nairn Falls station on the Spanish river, and the Wahnapitae Power Company carried well towards completion a new development of 7,000 h.-p. on the Wanapitei river.

In the extreme westerly part of the province the Backus-Brooks Company completed a remodelling of its plant on the Winnipeg river at Kenora, bringing the capacity to 12,000 h.-p. Most of this power is used in the company's extensive pulp and paper mills at Kenora.

Quebec.—The year 1924 has been the most active in water-power activities in the history of Quebec province. This applies not only to new water-power installations actually brought into operation amounting to some 175,000 h.-p. but in greater measure to developments actually under construction and nearly completion.

Of the developments completed and brought into operation during the year the largest was that of the St. Maurice Power Company at La Gabelle on the

St. Maurice river with an installation of 120,000 h.-p. This plant embodying the most up-to-date features of hydro-electric design was constructed in record time well in advance of the preliminary program. All of the output has been contracted for by the Shawinigan Water & Power Company.

In the northwestern part of the province the Quinze Power Company, a subsidiary of the Northern Canada Power Company, completed the initial installation of 20,000 h.-p. in its development of the Quinze river. This power is being transmitted for use in the Porcupine gold mining area of Ontario.

The Montreal Light, Heat and Power Consolidated added two units of 11,300 h.-p. each to its Cedars Rapids plant on the St. Lawrence river, thus completing the designed capacity of this plant of 18 units, totalling 200,000 h.-p.

On the North river two new plants were brought into operation, the first by the Laurentian Hydro-Electric Company near St. Marguerite with an initial capacity of 1,865 h.-p. and the second by J. C. Wilson Limited near St. Jerome with an installation of 1,200 h.-p.

Other new installations were those of the St. Regis Paper Company near Godbout on the lower St. Lawrence, 600 h.-p.; the town of Buckingham, 600 h.-p.; the town of Bagotville in the lake St. John district, 1,350 h.-p.; the town of Jonquiere in the same district, 1,800 h.-p.; and an addition of 7,500 h.-p. to the plant of the Ottawa and Hull Power Company at Chaudiere falls on the Ottawa river.

Among the numerous plants under construction and nearing completion the most outstanding is that of the Duke-Price Power Company at the Grand Decharge on the Saguenay river. It is expected that the initial installation of eight units totalling 360,000 h.-p. will be in place ready for operation during 1925. A large part of this power has been already contracted for by Price Brothers and Company for use in the company's extensive pulp and paper mills in this district.

The Ottawa River Power Company's plant on the Ottawa river near Bryson was nearing completion at the end of the year. This plant will have an initial installation of 25,700 h.-p., the most of which will be transmitted for use in Ottawa and Hull.

The Southern Canada Power Company made excellent progress with its new 37,800-h.p. development at Hemming falls on the St. Francois river. The first two units are in operation and the remaining four will shortly be completed. The same company also plans to add two units of 6,000 h.-p. each to its plant at Drummondville during 1925.

The Portneuf Hydraulic Company is installing 4,000 h.-p. in its plant at St. Alban on the Ste. Anne-de-la-Perade river. This work was delayed by the heavy floods of September, 1924.

Among projects just being commenced attention may be drawn to one by the Shawinigan Water and Power Company on the Batiscan river near St. Narcisse. This plant will have an initial capacity of 20,000 h.-p. with an ultimate possibility of 30,000 h.-p. Other projects include a development for the Canada Paper Company at Ulverton rapid on the St. Francois river, one for the town of La Tuque on the Bostonnais river, one for the municipality of Lac Bouchette south of lake St. John, one by the town of Coaticook on the river of the same name, one at Stoneham for the city street lighting of Quebec city, and one on the St. Esprit river near L'Epiphanie.

A review of the water-power activities in Quebec is not complete without a reference to the very important work being carried on by the Quebec Streams Commission in the creation of storage reservoirs. The commission has already in operation reservoirs of large magnitude on the St. Maurice and St. Francois rivers and of lesser size on the Ste. Anne-de-Beaupre river. During 1924 the Lake Kenogami reservoir was carried well towards completion. This will regulate the flow of the Chicoutimi and Sable rivers and when completed in

1925 will have a total capacity of 13 billion cubic feet. The commission also completed the Metis reservoir with a capacity of over 2¾ billion cubic feet, which will regulate the flow of the Metis river.

Among other storage projects on which the commission may shortly commence work may be mentioned Lac Sorcier reservoir on du Loup river, another in the Ste. Anne-de-la-Perade basin, lake Masson on the North river, and lake Mekinac on the St. Maurice river.

New Brunswick.—No new water-power construction was carried out in the province during the year but studies were actively proceeded with by the New Brunswick Electric Power Commission in connection with the project to develop Grand falls on the St. John river. This scheme which involves both international and inter-provincial problems is being thoroughly investigated and from every aspect before a start is made in actual construction.

During the year the town of Campbellton entered into a contract with the Lower St. Lawrence Power Company for a block of 1,100 h.-p. from the company's hydro-electric plant on the Metis river in Quebec. The power is delivered over the lines of the Matapedia Valley Light and Power Company to the Quebec-New Brunswick boundary and from thence to Campbellton over a 13-mile transmission line built by the town itself.

Among other projects under study in New Brunswick may be mentioned one by the Bathurst Company, Limited, at Pabineau falls on the Nipisiguit river.

Nova Scotia.—Outstanding in the year's activities in the province were the works carried on by the Nova Scotia Power Commission. On the East River Sheet Harbour the Malay Falls development of 5,500-h.p. capacity was completed and the power brought into service in a number of municipalities in Pictou county. On the same river a development at Ruth falls with an initial capacity of 6,290 h.-p. was completed. This power will be used in a mill being constructed in the vicinity by the Albany Perforated Wrapping Paper Company. The commission also added a 150-h.p. unit in its Mushamush plant and made extensive repairs to certain of the storage works in its St. Margaret Bay system.

Other hydro-electric activities in Nova Scotia during 1924 included the installation of a 100-h.-p. plant for the town of Chester on the East river, Chester, the alteration of the town of Bridgewater's plant to include two new 300-h.p. units, one of which replaces an old unit, and improvements in the town of Middleton's plant including the addition of a 400-h.p. unit.

Utilization of Developed Water-Power

The 3,569,275 h.-p. at present installed throughout the Dominion is apportioned to the following uses (see table 2):—

2,696,997 h.-p. in central electric stations for general distribution for domestic, municipal and commercial lighting and power purposes;

503,039 h.-p. installed in pulp and paper mills. In addition there is used in pulp and paper mills 228,755 h.-p. purchased from central electric stations.

369,239 h.-p. installed in industries other than central electric stations and pulp and paper mills.

The total installation for the Dominion averages 386 h.-p. per thousand population, a figure which places Canada among the leading countries of the world in per capita utilization of water-power.

Water-Power in the Central Electric Station Industry

As indicated by the foregoing classification by far the most important use to which the development of water-power has been applied in Canada has been

in connection with the central electric station industry. The extensive economic radius of modern electrical transmission combined with the fortunate location of water-power in relation to centres of industry removed from supplies of native fuel has led to the development of enormous amounts of hydraulic power for use in manufacturing in established centres where labour is plentiful and of a permanent character, with shipping and distributing facilities readily at hand. Such centres with their varied manufacturing needs and processes, electric railways to be operated, buildings to be lighted and heated, together with the various municipal power requirements for street lighting, water pumping and similar services form an ideal market for the product of the central electric station industry with the result that over 75 per cent of Canada's total hydraulic installation is available for public use through the medium of these distributing agencies. The special adaptation of hydraulic power to central electric station operations is further emphasized by the fact that over 95 per cent of the total primary power installation of Canadian central stations is hydraulic power.

Throughout the Dominion at the present time there are 291 hydro-electric central stations with a total turbine installation of 2,696,997 h.-p. and a generator installation of 2,046,104 kv.a. (see table 3). Of these totals 208 stations of a total capacity of 1,832,736 h.-p. are owned by commercial organizations and 83 of a total capacity of 864,261 h.-p. by municipal or other public organizations.

The turbines vary in size from the 10-h.p. wheel used for hamlet lighting to the great 55,000-h.p. units of the Chippawa-Queenston station and each year sees an increase in the average horse-power per turbine unit and also in the average horse-power installed per station.

Water-Power in the Pulp and Paper Industry

Perhaps the most conspicuous feature of recent industrial progress in Canada has been the growth of the pulp and paper industry due to the fortunate occurrence of tremendous supplies of growing pulpwood in close proximity to readily developable water-powers of a size to provide the large amounts of power essential to the conversion of the raw material into the finished product. The importance of ample supplies of low priced power lies in the fact that it takes practically 100 h.-p. per ton of daily output of newsprint. A recent development of interest affecting the power consumption of this industry is the rapid adoption of electric steam boilers as a means of transforming any surplus of available electric energy into steam for pulp cooking, drying, heating, etc. Generally speaking steam cannot be produced by electricity as ordinarily sold on the kw.h. basis in direct competition with coal, except where surplus power can be contracted for at a low rate, but large consumers of electrical energy commonly buy blocks of power on a flat contract over an extended time to cover their normal or future requirements and on Sundays, or when business conditions demand a reduced scale of operation, the surplus can be profitably converted into steam. Similarly those mills which maintain their own hydro-electric equipment are provided with an advantageous use for any surplus power which they may be able to generate from the water at their disposal.

There are 122 pulp and paper mills operating in Canada by hydraulic or hydro-electric power, utilizing a total of 731,794 h.-p. This is made up of 503,039 h.-p. installed by the mills themselves and 228,755 h.-p. purchased from hydro-electric central stations. The rapid development of the electric drive in this industry is indicated by the fact that 215,472 h.-p. of the installation in the mills is connected to generators which added to the 228,755 h.-p. purchased power gives a total electric drive of 444,227 h.-p. or over 60 per cent of the power used.

Past Growth in Utilization of Water-Power

The growth of water-power development in Canada has been most striking and there is every reason to believe that the rapid adaptation of electricity to new uses will greatly accelerate the past rate. Chief among these new uses may be enumerated the electrification of steam railroads, the application of electric heat to manufacturing processes and the extension and use of electrically heated steam boilers for process steam. Canada's strategic advantage in the location of large reserves of water-power within transmission distance of her centres of population should attract special industries to these centres in increasing numbers, and the added population accruing therefrom would at once create an added market for power for domestic and municipal uses.

The total installed horse-power in Canada has grown from 975,000 h.-p. to 3,569,275 h.-p. since 1910, central electric station installation from 605,000 to 2,696,997 h.-p. and pulp and paper mill installation from 191,000 to 503,039 h.-p.

Capital Invested in Water-Power

The investment represented by our present hydraulic installation of 3,569,275 h.-p. has been recently made the subject of an intensive study, based largely, on the figures of the annual census of hydro-electric central stations. Due allowance being made for all the varying factors entering into the development and use of hydraulic power warrants the statement that a conservative estimate of the capital investment in Canadian water-power developments amounts to $767,000,000.

Table 1.—Available and Developed Water Power in Canada, February 1, 1925.

Province	Available 24-hour power at 80 per cent efficiency		Turbine installation H.-P.
	At ordinary min. flow H.-P.	At ordinary 6-months flow H.-P.	
1	2	3	4
British Columbia	1,931,142	5,102,460	355,722
Alberta	475,281	1,137,505	34,107
Saskatchewan	513,481	1,087,756	35
Manitoba	3,270,491	5,769,444	162,025
Ontario	4,950,300	6,808,190	1,585,182
Quebec	6,915,244	11,640,052	1,308,106
New Brunswick	50,406	120,807	44,656
Nova Scotia	20,751	128,264	63,957
Prince Edward Island	3,000	5,270	2,276
Yukon and Northwest Territories	125,220	275,250	13,209
Canada	18,255,316	32,075,998	3,569,275

The figures listed in columns 2 and 3 in the above table represent 24-hour power and are based upon rapids, falls and power sites of which the actual existent drop or the head possible of concentration, is definitely known or at least well established. Many rapids and falls of greater or lesser power capacity are scattered on rivers and streams from coast to coast which are not as yet recorded, and which will only become available for tabulation as more detailed survey work is undertaken and completed. This is particularly true in the relatively unexplored northern districts. Nor is any consideration given to the power concentrations which are feasible on rivers and streams of gradual gradient, where economic heads may be created by the construction of power dams, excepting only at such points as definite studies have been carried out and the results made matters of record.

The figures in column 4 represent the actual water wheels installed throughout the Dominion. These figures should not be placed in direct comparison with the available power figures in columns 2 and 3 for the purpose of deducting therefrom the percentage of the available water-power resources developed to date. The actual water-wheel installation throughout the Dominion averages 30 per cent greater than corresponding maximum available power figures calculated as in column 3. The figures quoted above, therefore, indicate that the *at present recorded water-power resources* of the Dominion will permit of a turbine installation of 41,700,000 h.-p. In other words, the present turbine installation represents only $8\frac{1}{2}$ *per cent* of the present recorded water-power resources.

The above figures may be said to represent the *minimum water-power possibilities of the Dominion.*

As illustrative of this the detailed analyses which have been made of the water-power resources of the provinces of New Brunswick and Nova Scotia have disclosed most advantageous reservoir facilities for regulating stream flow and it is estimated that the two provinces possess within their respective borders 200,000 and 300,000 commercial horse-power. These figures provide for a diversity factor between installed power and consumers' demands.

Table 2.—Developed Water Power in Canada, February 1, 1925

Province	Turbine Installation in H.-P.				Population June 1, 1924	Total installation per 1,000 population
	In central stations	In pulp and paper mills	In other industries	Total		
1	2	3	4	5	6	7
British Columbia	242,401	55,140	58,181	355,722	553,000	643
Alberta	33,340	....	767	34,107	637,000	54
Saskatchewan	....	....	35	35	815,000	·04
Manitoba	145,625	....	16,400	162,025	647,000	250
Ontario	1,246,203	178,989	159,990	1,585,182	3,062,000	518
Quebec	965,110	237,851	105,145	1,308,106	2,480,000	527
New Brunswick	23,613	13,728	7,315	44,656	399,400	112
Nova Scotia	30,417	17,331	16,209	63,957	533,000	120
Prince Edward Island	288	....	1,988	2,276	87,700	26
Yukon and Northwest Territories	10,000	....	3,209	13,209	12,040	1,100
Canada	2,696,997	503,039	369,239	3,569,275	9,226,740	386

Column 2 includes only hydro-electric stations which develop power for sale.

Column 3 includes only water power *actually developed* by pulp and paper companies. In addition to this total, pulp and paper companies purchase from the hydro-power central stations totalled in column 2. 96,985 h.-p. in Ontario; 131,120 h.-p. in Quebec, and 650 h.-p. in New Brunswick. The total hydro power utilized in the pulp and paper industry is therefore 731,794 h.-p.

Column 4 includes only water power *actually developed* in connection with industries other than the central station and pulp and paper industries. These industries also purchase blocks of power from the central stations totalled in column 2.

Column 5 totals all turbines and water-wheels installed in Canada.

Column 6 population at June 1, 1924, as estimated by the Dominion Bureau of Statistics.

Column 7 averages the developed water-power per 1,000 population. If population estimated to Feb. 1, 1925, total installation per 1,000 population in Canada becomes 383.

Table 3.—Developed Water Power in Canada utilized in the Central Electric Station Industry, February 1, 1925

Province	Commercial stations			Municipal stations			Total				
	No.	Installation		No.	Installation		No.	Installation			
		Generators Kv-a	Turbine H.-P.		Generators Kv-a	Turbine H.-P.		Generators Kv-a	H.-P. per turbine unit	H.-P. per station	Total turbine H.-P.
1	2	3	4	5	6	7	8	9	10	11	12
British Columbia	24	153,686	232,356	8	6,353	10,045	32	160,039	4,108	7,375	242,401
Alberta	3	22,250	32,380	1	850	960	4	23,100	2,223	8,337	33,340
Saskatchewan	......	....	....	......	....	....	......	....	....	....	....
Manitoba	4	58,350	78,400	2	57,312	67,225	6	115,662	6,935	24,271	145,625
Ontario	70	409,084	519,975	38	529,122	726,228	108	938,206	4,327	11,539	1,246,203
Quebec	82	744,963	943,785	18	15,962	21,325	100	760,925	4,089	9,651	965,110
New Brunswick	7	8,460	11,703	3	9,363	11,910	10	17,823	1,073	2,361	23,613
Nova Scotia	10	3,279	3,849	13	20,739	26,568	23	24,018	895	1,322	30,417
Prince Edward Island	7	331	288	......	....	....	7	331	32	41	288
Yukon and Northwest Territories	1	6,000	10,000	......	....	....	1	6,000	5,000	10,000	10,000
Canada	208	1,406,403	1,832,736	83	639,701	864,261	291	2,046,104	3,932	9,268	2,696,997

Commercial stations include all privately owned.

Municipal stations include all publicly owned.

NOTE.—The statistics in this table are based upon a census of the industry made by the Dominion Bureau of Statistics in co-operation with the Dominion Water Power and Reclamation Service.

Table 4.—Developed Water Power in Canada utilized in the Pulp and Paper Industry, February 1, 1925

Province	No. of mills	Installed and purchased power—H.-P.					
		Turbine installation in the industry			Purchased hydro-elec. power	Total hydro-elec. power used Co. 4 and Col. 6	Total hydraulic power utilized Col. 5 and Col. 6
		Direct drive	Hydro-elect. drive	Total			
1	2	3	4	5	6	7	8
British Columbia	5	26,790	28,350	55,140	....	328,350	55,140
Ontario	46	89,066	89,923	178,989	96,985	186,908	275,974
Quebec	57	151,792	86,059	237,851	131,120	217,179	368,971
New Brunswick	4	2,668	11,060	13,728	650	11,710	14,378
Nova Scotia	10	17,251	80	17,331	....	80	17,331
Canada	122	287,567	215,472	503,039	228,755	444,227	731,794

Column 3 includes all turbines actually installed in the industry and directly driving mill equipment.
Column 4 includes all turbines actually installed in the industry and transmitting power through electric drive.
Column 5 totals the turbine capacity actually installed in the industry.
Column 6 includes only power purchased from hydro-electric central stations for the operation of pulp and paper mills.
Column 7 totals the hydro-electric power used in the industry.
Column 8 totals the water-power used in the industry.

Census of the Central Electric Station Industry

Accurate, up-to-date information as to the status and development of the central electric station industry of Canada is of prime importance for three outstanding reasons, viz.:—

1. Over 75 per cent of Canada's total hydraulic installation is installed in central electric stations for general distribution for domestic, municipal and commercial lighting and power purposes.
2. Over 94 per cent of the total main plant primary power installation in central electric stations is hydraulic turbines.
3. Over 97 per cent of the total electrical output of the central electric stations is produced from water-power.

In order to obtain this information an annual census of this industry is conducted by this service in co-operation with the Dominion Bureau of Statistics as part of the census of industry conducted by the bureau. The seventh annual census was completed during the past year and a general statistical analysis showing the status of the industry as at January 1, 1924, published.

The demand for the Directory of Central Electric Stations published under date of November 1, 1922, has been very great during the year just completed and owing to the rapidly changing conditions in the central station industry inquiries are already being received as to the probable date of issue of a revised edition.

Dominion Hydrometric Survey

The Dominion Hydrometric Survey embraces all the provinces of Canada. In the provinces of Manitoba, Saskatchewan and Alberta, the work is a direct responsibility of the Federal Government and in the other provinces it is carried on under co-operative agreements. Throughout the Dominion standard methods are used both in the field activities and in office administration and water-resources information is available to the public at one central source. The arbitrary divisions of provincial boundaries are eliminated and the country is

divided into the more logical divisions of major drainage. The main drainage divisions, together with the location of the district office or offices in charge, are as follows: Pacific drainage, Vancouver, Artic and Western Hudson Bay drainage, Calgary and Winnipeg; St. Lawrence and Southern Hudson Bay drainage, Ottawa and Montreal; Atlantic drainage, Halifax.

The increasing utilization of water resources, for diversified and often conflicting purposes, and particularly in connection with power development and irrigation projects, has created a pressing demand for detailed and extensive records of the regimen of the numerous lakes and rivers of the country. The voluntary co-operation of numerous individuals and private corporations is a recognition of the importance of stream-flow records.

Run Off Conditions in Canada.—The detailed reports of the district chief engineers, printed further on in this publication, show that the average run-off for the year has been normal in British Columbia, below normal in Alberta, Saskatchewan, Manitoba and Ontario, above normal in Quebec and about normal in the Maritime Provinces. The distribution of run-off throughout the year was, however, at variance with average conditions, in parts of Quebec and the Maritime Provinces, low run-offs were recorded in the spring and heavy floods occurred in the autumn.

Power and Storage Investigations.—In connection with power and storage studies, described later on in the detailed reports of the district chief engineers, field investigations were carried out only where urgently required or in response to special requests from organizations receiving co-operative assistance from the service. Office studies of the undeveloped and developed water-power resources of the Dominion were, however, actively prosecuted with the object of keeping such records thoroughly up to date.

Flooded Land Contours.—The survey of the boundaries of lands required for flooding in connection with the development of power was continued during the year 1924.

The season's operations were confined to that portion of the main channel of the Winnipeg river known as the Seven Sister's section, extending from the fifth fall up stream to the main diversion dam. The survey was commenced on the east boundary of sections 27 and 34, in township 13, range 11, at the point where the work was suspended in 1922, and was continued through tp. 13, rge. 11, tps. 13 and 14, rge. 12, and tp. 13, rge. 13, and was closed on the north boundary of sec. 31, tp. 13, rge. 13. The north boundary of the reserve was closed on traverse station No. 71, of the 1921 survey, on the east boundary of sec. 4, tp. 14, rge. 12, all east of the Principal Meridian.

The proposal to develop power at Upper Seven Sisters necessitates the reservation of the whole of sec. 36, tp. 13, rge. 11, E., for purposes of construction. West of this point, as far as the Lower Seven Sister's site, elevation 875 feet has been fixed as the limiting flood contour and east of this point as far as the Upper Pinawa site and the Slave Falls site the flood contour has been fixed at 905 feet elevation. In both cases 5 feet is allowed as a factor of safety, the proposed elevation of headwater being 870 and 900 feet respectively.

The traverse of the reserve boundaries was accompanied by a re-survey of the boundaries of all sections cut by the traverse and including the alternate chords not run in the original survey. All lines of both the subdivision and the traverse were run with the transit and chain and all levels were taken with a wye level. All section and quarter-section corners, and all traverse corners on vacant land were posted with standard survey posts.

There is a break in the 905-foot contour on both sides of the river immediately above the damsite. The break on the south side was fully examined in 1921 and reported on, while that on the north side was examined this season by

means of a series of levels over secs. 4, 5 and 6, tp. 14, rge. 12. The total length of embankment required to close the break on the south side is 9,500 feet and on the north side 9,400 feet, making a total of about 3.6 miles.

Within the area surveyed this season all lands likely to be affected by flooding are vacant except the NE. ¼ sec. 26, and NW. ¼ sec. 25, tp. 13, rge. 11, the S. ½ sec. 32 and S. ½ and NW. ¼ sec. 26, tp. 13, rge. 12, E.

Owing to the low swampy nature of the land in the eastern part of tp. 13, rge. 12, the 905-foot contour swings far to the south and it was necessary to include in the reserve an extensive area of swamp in secs. 21, 22, 23, 25, 26 and 27. At this point there are some small areas of land within the boundaries of the reserve which are above the elevation of the limiting contour. It is proposed, however, that these areas shall be reserved for the present, although above the elevation required for flooding.

The total length of section lines surveyed this season amounts to 54.5 miles while the total length of traverse lines amounts to 41.3 miles. Five additional miles of line were cut for levelling operations other than those carried out along the traverse and section lines. This makes the total mileage 100.8.

The survey was carried out under the instructions of the Surveyor General.

(*b*) FIELD REPORTS

District of British Columbia

R. G. Swan, District Chief Engineer

ORGANIZATION

During the fiscal year ending March 31, 1925, regular hydrometric investigatory operations of the Dominion Water Power and Reclamation Service in the province of British Columbia have been continued, consistent with the terms of the co-operative agreement between the department and the Provincial Government.

Field operations and works are directed from the head office at Vancouver, with a branch office at Kamloops. While the object of the organization is primarily the acquisition and tabulation of stream-flow data for use in the study of power developments, irrigation, reclamation and domestic water supply, the services of engineers of this staff are frequently utilized for other government departments which are without engineers in British Columbia.

The greatest amount of work for other departments is performed for the Department of Indian Affairs, in connection with the adjustment of Indian water rights in British Columbia, as well as the installation of irrigation systems, water supply, sewage disposal and electric lighting plants on Indian reserves. During the past year one, and frequently two engineering parties have been maintained in the field, in addition to an engineer devoting his whole time to the adjustment of Indian Water Rights before the Provincial Board of Adjudication under the British Columbia Water Act.

CO-OPERATION

All the hydrometric studies in British Columbia are made by this service with the co-operation of the Provincial Government. Stream-flow data are supplied to the Comptroller of Water Rights at Victoria, and District Water Rights engineers throughout the province, continuously throughout the year, and a complete record of all streams is annually supplied to the comptroller.

Gauging stations have been maintained in co-operation with the Water Resources Branch of the United States Geological Survey on the Columbia, Pend d'Oreille (Clark Fork) and Okanagan rivers, which are all very important international streams.

Extensive hydrometric investigations have been carried on in co-operation with the British Columbia Electric Railway Company in Bridge River district. Six regular gauging stations have been established and miscellaneous records obtained on 13 other streams. All field expenses in this connection are, by arrangement, being paid by the company.

In co-operation with the city of Vancouver, further hydrometric investigations are being carried on to determine the most economic power sites within reasonable transmission distance of the city. All expenses in connection with the maintenance of gauging stations for the city, are being borne by the city.

Continuing the economical co-operation with the Department of Indian Affairs, good progress has been made toward final settlement of Indian water claims. Applications are being filed from time to time for additional rights to benefit the reserves throughout the dry belt in the interior of the province, and the abandonment of confirmed water records, which are of no practical value, is being recommended. Innumerable matters arising out of, or incidental to the hearings of the Board of Investigation have been attended to, and many questions of dispute between Indians and other water users as to the division of irrigation water have been amicably settled. Inspections and surveys in connection with utilization of water under licenses granted or pending, either by improvement to existing systems or under new projects, have received particular attention.

During the year ended March 31, 1925, 96 conditional licenses were issued as appurtenant to Indian reserves. Of this number, 86 were issued under board orders in confirmation of claims to water rights, and the remainder were issued by the comptroller under new applications as follows:—

Agency	Under Board orders	Under application	Licenses issued
Lytton	46	3	49
Kamloops	25		25
Okanagan	1		1
Williams lake	14	6	20
Kootenay		1	1
			96

New applications for licenses filed during the same period totalled 15. Of this number 7 have been granted and 8 are pending as shown hereunder:—

Agency	Number filed	Number granted	Number pending
Lytton	4	3	1
Kamloops	3	2	1
Okanagan	1	0	1
Williams lake	5	2	3
Kootenay	2	0	2
	15	7	8

A total of 280 conditional water licenses have been issued for Indian reserves in the province, to date.

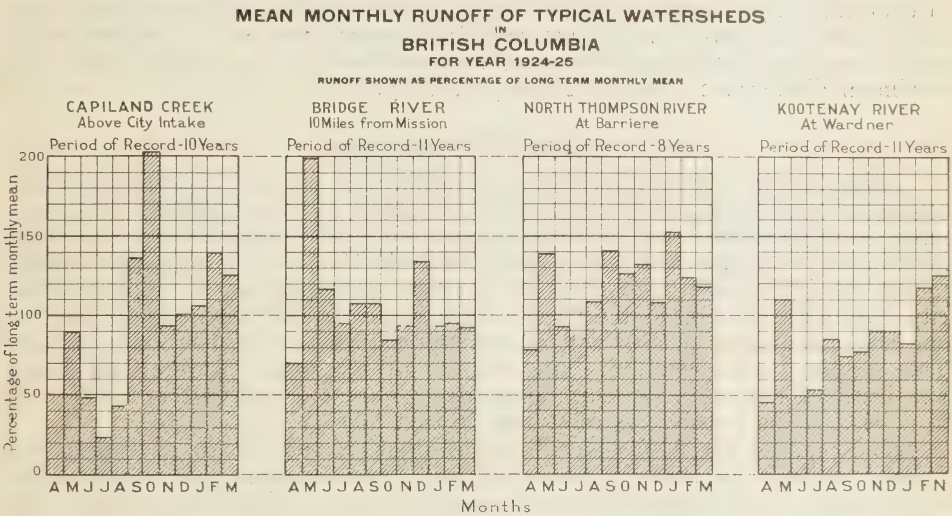
HYDROMETRIC SURVEYS

During the year ended March 31, 1925, 174 regular stations were maintained on rivers and tributaries in the following main watersheds: Columbia, Fraser, Kettle, Kootenay, North Thompson, Okanagan, Pacific Coast (mainland), Similkameen, South Thompson, Thompson, Lillooet, and Vancouver island.

Many of these stations were maintained for more than one purpose. Forty-two stations were maintained for power, 134 for irrigation, 2 for drainage and reclamation, 7 for domestic supply, 7 for flood purposes, 2 for navigation, 4 for international problems, and 5 for statistical purposes. There were 24 new stations established and 2 discontinued. Of the new stations 7 were established at the request of the British Columbia Electric Railway Company, in connection with a power survey of the Bridge River drainage, and 5 at request of the city of Vancouver for their hydro-electric investigations. The remainder were established at the request of the Provincial Water Rights Branch in connection with water-power investigations and irrigation problems throughout the province.

The temperature throughout British Columbia during the past year has been above normal, with the exception of the Kamloops district, where it equalled the mean for the past ten years or more. The precipitation for the year in the coastal and Kootenay areas was below normal and in the Bridge River and North Thompson areas it was above normal.

PLATE 1



In the coastal and central Fraser area the total run-off for the year ending March 31, 1925, was about normal; while in the North Thompson area it was considerably above normal; and in the Kootenay area, below normal. The following are 4 typical stations in the pacific drainage, namely: Capilano creek near Vancouver, Bridge river near Lillooet, North Thompson river at Barrier, and the Kootenay river at Wardner (see plate 1).

In the coastal area, as typified by Capilano creek, which has a drainage area of 64 square miles, low precipitation and run-off were recorded, the former being 95 per cent of the long-term mean and the latter 96 per cent. Flood run-off reached a maximum daily mean discharge of 173 sec.-ft. per square mile in October as compared with 264 sec.-ft. in October, 1921. The low run-off, which occurred in September, was at the rate of 0.66 sec.-ft. per square mile as compared with 0.56 sec.-ft. in September 1915 and 1923, the minimum discharge recorded during the past 10 years.

In the Central Fraser basin, as typified by Bridge river which has a drainage area of 1,900 square miles, a precipitation and run-off above the average was recorded, the former being 127 per cent of the long-term mean and the latter 108 per cent. The flood run-off reached a maximum daily mean discharge of 7.89 sec-ft. per square mile in July as compared with 13.7 sec.-ft. in June 1918.

The low run-off, which occurred in December, was at the rate of 0.247 sec.-ft. per square mile as compared with 0.189 sec.-ft. in November, 1918, the minimum discharge record for the past 10 years.

In the North Thompson River basin, as typified by the North Thompson river at Barrier, which has a drainage area of 7,000 square miles, precipitation and run-off above normal were recorded, the former being 147 per cent of the long-term mean, and the latter 117 per cent. The flood run-off reached a maximum daily mean discharge of 8.33 sec.-ft. per square mile in May as compared with 11.15 sec.-ft. in June, 1921. The low run-off, which occurred in February, was at the rate of 0.40 sec.-ft. per square mile, as compared with 0.214 sec.-ft. in March, 1919, the minimum discharge recorded for the past 11 years.

In the Upper Kootenay basin, as typified by Kootenay river at Wardner which has a drainage area of 5,200 square miles, low precipitation and run-off were recorded, the former being 83 per cent of the long-term mean and the latter 82 per cent. The flood run-off reached a maximum daily mean discharge of 6.02 sec.-ft. per square mile in May as compared with 13.0 sec.-ft. in June, 1916. The low run-off which occurred in January, was at the rate of 0.27 sec.-ft. per square mile, as compared with 0.12 sec.-ft. in January 1914, the minimum discharge recorded for the past 11 years.

SPECIAL INVESTIGATIONS

Hydrometric investigations in co-operation with the city of Vancouver and others in co-operation with the British Columbia Electric Railway Company have already been referred to; in addition the city of Vancouver has carried on an exhaustive study of the storage possibilities in Capilano and Seymour creeks, in anticipation of a large expenditure to ensure a reliable water supply for the city. At the beginning of the year, a by-law was carried providing the sum of one and one-quarter million dollars for improvements to water-supply system. This service has co-operated in the run-off investigations. A recording gauge was installed during the summer on Burwell lake at an altitude of 2,800 feet, to determine the possibilities of storage in that lake.

The plan of the Vancouver Districts Joint Sewage Board, for proposed drainage scheme for Burnaby Lake and Still Creek areas in the municipalities of Burnaby and Coquitlam, as well as the city of New Westminster, was reported upon.

Further investigations into the storage possibilities in the Kootenay lake, for power purposes at Kootenay river below Nelson, were made. This study covers the investigation into flow of all tributaries of the Kootenay Lake area, as well as the flow in Kootenay river itself above the international boundary at Port Hill, Idaho. Due to the inter-relation of the power and reclamation interests, it is necessary to carry on intensive hydrometric investigations so that, if possible, a solution satisfactory and beneficial to both interests, may be found.

An investigation was made as to the feasibility of pumping water for irrigation purposes from the South Thompson river near Neds creek.

The effect of the flood, in month of December, within coastal area was investigated and reported upon. Some serious damage was done in the Sumas district.

DEPARTMENT OF INDIAN AFFAIRS

Forty-seven investigations and surveys were conducted during the year on behalf of the Department of Indian Affairs. These investigations covered a wide range in engineering, including water storage, irrigation, domestic water supply, river bank protection, electric lighting and sewage disposal for Indian industrial schools and Indian reserves.

Where required, plans, estimates of cost and specifications have accompanied reports on proposed works for the consideration of the department, and several agreements covering the construction, maintenance or operation of works owned or used jointly with other interests, have been prepared. Considerable construction work resulting from these investigations has been carried out during the year, both with respect to new projects and repairs to existing works.

Typical projects may be cited as follows:—

Water Storage.—A control dam at the outlet of Pinaus lake was designed to impound 2,000 acre-feet of water to be used for irrigation purposes on Okanagan Indian reserve No. 1 and lands belonging to G. Massey, of Vernon, B.C. All the various details ranging from water rights to an agreement covering the construction, operation and maintenance of these joint works are being attended to, and it is anticipated that construction will be undertaken and completed after the close of the coming irrigation season.

Irrigation.—A water-supply system from Bridge and Matthews creeks to irrigate approximately 1,000 acres of land on Canim Indian reserve No. 1 has been investigated. Necessary surveys, plans, estimates of cost, etc., were submitted and it is anticipated that construction will be undertaken, if it is found that the available water supply warrants the expenditure involved.

River Bank Protection

Works to prevent further erosion of the banks of St. Marys river to protect land on Kootenay Indian reserve No. 1 are now under construction. Considerable difficulty has been encountered due to log jams and ice conditions causing flooding, with resultant damage to partially completed protection work. Every endeavour is now being made to complete the work of construction in time to take care of the heavy run-off during the coming season.

Electric Lighting

A plant to provide electric lighting for the Indian village at Cape Mudge (We-way-akay Indian reserve No. 10) has been installed and is giving entire satisfaction. Power is supplied by a 12-h.p. Petter engine connected to a 7-kilowatt 125-volt generator suitably housed.

Sewage Disposal

A sewage disposal system was installed for the Kamloops Industrial school. This consists of a re-inforced concrete, 2-chambered septic tank with automatic syphon discharging 4 times per day into a disposal bed of sub-surface tile drain, laid for a distance of 3,000 feet. This system is capable of disposing of 10,000 gallons of sewage per day, which is considered ample to provide for school requirements and is giving satisfaction.

Our records during the past year have been in increasing demand throughout the province, there being considerable revival in hydro-electric investigations and this office is called upon from time to time for hydrometric data on power streams throughout the province. In the interior, with a shortage of water for irrigation purposes in many districts, records from this department are being utilized more and more in the adjustment of water rights and the distribution of water to the water users. The hydrometric records have also been in request by some of the larger cities of the province in connection with questions of domestic water supply.

District of Alberta and Saskatchewan

A. L. Ford, District Chief Engineer

ORGANIZATION

In addition to the irrigation and drainage activities, referred to in Part II, the stream measurement and power investigatory work of the Dominion Water Power and Reclamation Service in Alberta and Saskatchewan were continued during the fiscal year ended March 31, 1925.

The area covered from this district office comprises the province of Alberta, the Peace River Block in British Columbia and all the province of Saskatchewan, with the exception of the northeastern or Churchill River area which is supervised from the Manitoba office of the service.

The amalgamation of the Dominion Water Power Branch and the Reclamation Service in 1923 made it possible to combine all functions in regard to the investigation, utilization and administration of water resources under the control of a single field organization with headquarters in the Southam Chambers at Calgary. The large area above referred to has made it expedient to create sub-districts, each in charge of an engineer located therein who carries on the irrigation, drainage and water-power investigations in addition to hydrometric surveys. These officers report to and are controlled from Calgary, where all data are compiled.

CO-OPERATION

The same pleasant relations continued with the Montana Division of the United States Geological Survey and United States Reclamation Bureau in the co-operative collection of stream-flow data on the apportionment of international waters along the boundary between the provinces of Alberta and Saskatchewan and the state of Montana. These duties devolve on this service through the requirements of the International Joint Commission under the provisions of the International Waterways Treaty.

During the past fiscal year an active co-operative interest has been shown by other departments, the Provincial Governments, the large railway corporations and several municipalities. Both Provincial Governments have assisted in the obtaining of hydrometric records of special interest to them. The railways and municipalities have co-operated in obtaining data in regard to water-supply problems in which they were interested. Such co-operation enables the service to collect a large amount of data at little expense and at the same time is an assurance that the data being collected are of value.

The lectures and demonstrations on hydrometric and water-power methods carried out in previous years were again continued at both the University of Alberta and the University of Saskatchewan.

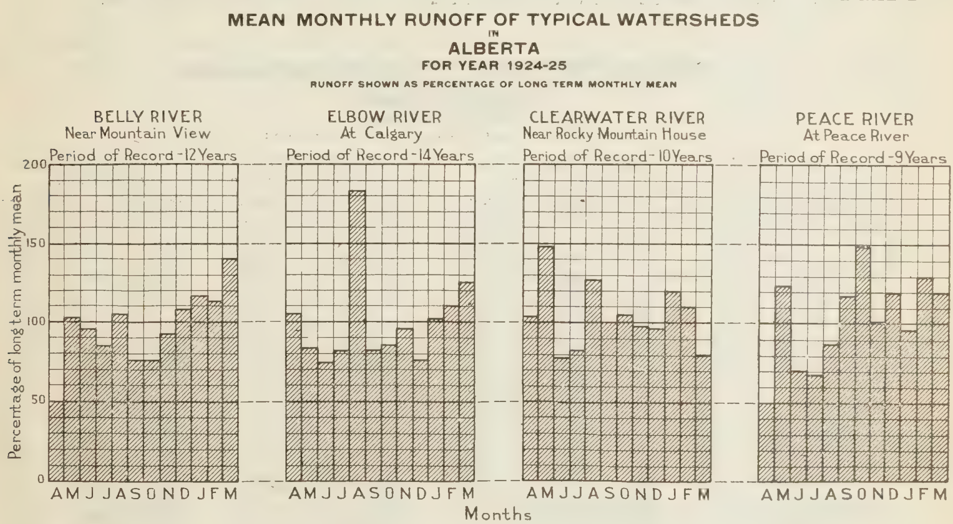
HYDROMETRIC SURVEY

During the fiscal year 1924-25 a total of 335 gauging stations were maintained for various periods on streams, lakes, canals, or ditches in the following main watersheds: Athabaska, Battle creek, Belly, Bow, Frenchman, Little Bow, Lodge creek, Milk, North Saskatchewan, Oldman, Peace, Qu'Appelle, Red Deer, Rock creek, Ross creek, St. Mary, Saskatchewan, Sevenpersons creek, South Saskatchewan, Swiftcurrent creek, and Waterton. Eleven of these gauging stations were maintained on streams and 2 on lakes or reservoirs throughout the year for power purposes. For irrigation purposes 12 stations on streams were maintained throughout the year, and 51 on streams, 10 on lakes or reservoirs, 25 on canals and 135 on ditches during the irrigation or

open-water season only. One station on a stream and 1 on a lake were maintained all year for drainage purposes, while for the same uses 14 stations on streams, 7 on lakes and 2 on ditches or canals were maintained during the open-water season. For the collection of data useful in connection with domestic, industrial or municipal water-supply problems, 5 all-year stations and 4 open-water stream stations were maintained. Four stations were maintained during the danger period in connection with flood warnings. For the purpose of carrying out the instructions of the International Joint Commission it was necessary to maintain gauging stations on 5 streams throughout the year and also 12 stations on streams, 1 on a reservoir, 3 on canals and 15 on ditches during the open-water season only. For statistical purposes 7 all-year stations on streams were operated while 3 on streams and 5 on lakes were maintained during the open-water season only.

The year opened with less than the usual run-off from most areas in both provinces, the preceding winter of 1923-24 having been quite open with a snowfall below normal. In fact several streams in the western Cypress hills did not

Plate 2



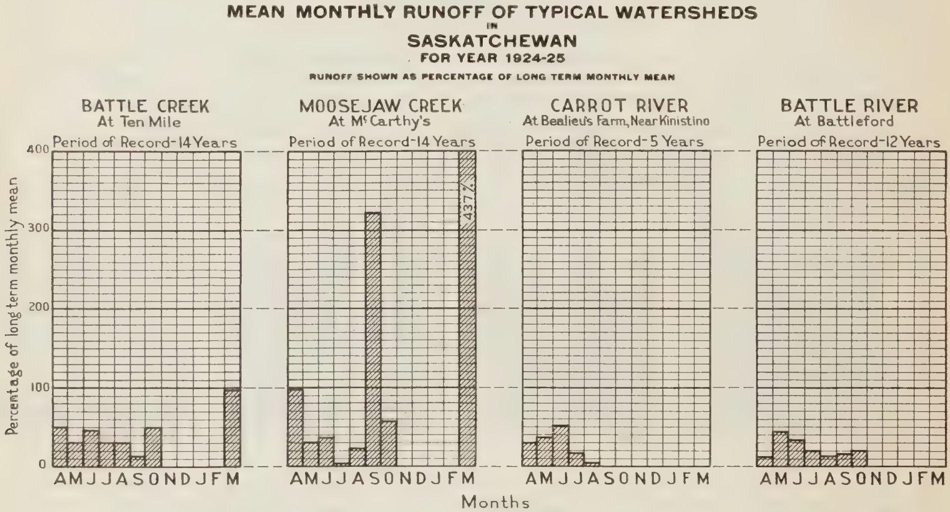
run at all and remained dry throughout the year until February, 1925. While some streams had an annual run-off below average others were slightly above average with the result that as a whole the run-off was very close to normal. During the summer there were many light storms which resulted in the ground water table being kept up and the resultant winter run-off being slightly above average. No storms of sufficient magnitude to cause floods or unusually high water occurred in either Alberta or Saskatchewan. The winter of 1924-25 has been noted for heavy snowfalls with few mild periods so that at the end of the fiscal year conditions are such that heavy run-offs may be encountered in streams which receive their chief source of supply from winter snows. Flood conditions developed during the last week in March, 1925, from this cause on the following streams in southern Saskatchewan: Wood river, Notukeu creek, Wiwa creek, Qu'Appelle river, Wascana creek, and Boggy creek. At the same time high-water conditions existed on Eaglehill creek in central Saskatchewan and Rosebud river in central Alberta.

The run-off conditions in both Alberta and Saskatchewan month by month are clearly shown on the accompanying graphs (see plates 2 and 3). These

graphs are for typical streams and are indicative of the general run-off conditions in the various areas covered by the survey. For southern Alberta the Belly river near Mountain View is shown while the south central portion of the province is represented by the Elbow river at Calgary. For the north central portion of Alberta, the Clearwater river near Rocky Mountain House and for northern Alberta, Peace river at Peace River have been chosen. Saskatchewan is covered by graphs of the following streams: for the southwestern or Cypress Hills area, Battle creek at Tenmile; for the southeastern part, Moosejaw creek; for the northeastern part, Carrot river; and for the northwestern portion, Battle river near Battleford.

The records of the typical stations show that in southern Alberta the run-off was below normal, that of the Belly river and the Elbow river being only 94.2 per cent of the long-term mean. In northern Alberta the run-off at the typical stations was about average, ranging from 101 per cent for the Clearwater to 92 per cent on the Peace. Precipitations varied as follows: 85 to 61 per cent of the mean in southern Alberta, 116 per cent in central Alberta, and 109 per cent in northern Alberta. Other than the unusually low run-offs in the western Cypress hills no abnormal run-offs occurred in Alberta.

PLATE 3



Saskatchewan run-offs, as indicated by the typical stations, were much below average. The Battle river in the northwestern portion of the province was only 23 per cent of the long-term mean, while the Carrot river, typical of the northeastern portion, was 32.6 per cent. In the southeastern part of the province Moosejaw creek had an 87 per cent run-off, while in the southwestern portion Battle creek at Tenmile was 48.0 per cent of average. Precipitations in Saskatchewan ranged from 65 to 84 per cent of the mean in the north and from 91 to 108 per cent in the south. No flood or unusual run-offs occurred in this province except in March, as stated above.

At Calgary the Dominion Water Power and Reclamation Service operates the only fully equipped current-meter rating station in Canada and here all instruments used by this service and many by other users of meters are rated. In addition the rating station equipment was utilized for the making of practically all repairs to meters belonging to the service. Meters are rated as received from the field, so that any recent measurements may, if necessary, be re-computed, and after any repairs have been made are then re-rated. In

the fiscal year 1924-25 a total of 93 current-meters were rated, 120 ratings made and 46 instruments repaired to a greater or less extent. The station was operated from May 1 to October 31, and in addition to the usual work, certain equipment in connection with the station was constructed or re-built. Of the meters rated 1 was for the University of British Columbia, 1 for the Water Rights Branch of British Columbia, 1 for the Lethbridge Northern Irrigation district, 6 for the Canadian Pacific Railway Company and the balance for the officers of this service, as follows: Maritime Provinces 3, Quebec 5, Ontario 16, Manitoba 5, Alberta and Saskatchewan 45, and British Columbia 10. Special ratings made during the year included that of a new type of current-meter as well as the determination of the behaviour of meters of various types, suspended on heavy rods.

SPECIAL INVESTIGATIONS

Since 1921 this service has assumed annually the responsibility for the operation of lake Minewanka during the filling period of the reservoir.

This responsibility was again assumed on May 2, 1924. Special steps were taken this year to facilitate the handling of stoplogs at the dam as the construction of a power plant on the Cascade river and the consequent alterations to the dam had reduced the spillway capacity to a considerable extent. The further precautions taken proved adequate under the normal conditions existing and the reservoir was so controlled that the water surface did not reach an excessive height but was brought to the required elevation by the opening of the tourist season.

A proposal has been advanced to develop power on the Belly river approximately in the SW. ¼ sec. 21, tp. 2, rge. 28, W. 4th mer. in conjunction with the Mountain View Irrigation scheme. In May, 1924, Mr. S. B. Smith made application for a permit to undertake this development. Considerable attention has been given to the water-power and irrigation phases of this joint proposal and studies have been made of the requirements. Owing to the delay on the part of the Irrigation district in determining its irrigation requirements, the report on the power phases of the scheme has been delayed. Data now at hand will allow this investigation to proceed. The proposed use of the power is for lighting, etc., of Cardston and neighbouring towns.

The 2 applications for power rights at Crowsnest falls on Crowsnest river in southeastern Alberta, which were under consideration at the beginning of the year, are still before the department.

Two applications for the right to develop storage and high-head power at Spray lakes in Bow River basin are still before the department. The 2 applicants for these privileges are the Montreal Engineering Company of Montreal, Quebec, and the Province of Alberta. In May a field inspection was made of the new transmission line location of the Calgary Power Company between Seebe and Calgary. The location was approved and construction completed in the fall. While no official inspection was made, district officers kept in touch with the alterations being made by the Calgary Power Company at their power plants and Calgary sub-station in order to meet the increasing power demands of the city of Calgary.

Numerous requests were received during the year for information regarding small power sites.

As in previous years an investigation of the absorption losses in lake Newell reservoir was made in co-operation with officials of the Canadian Pacific Railway Company's Eastern Irrigation section. The data collected have been compiled and a report on the results obtained to date will shortly be prepared.

With the object of determining carriage losses in large canals the investigation commenced in 1922 on the main canal of the Western Irrigation section of the Canadian Pacific Railway Company was continued in co-operation with officials of that company.

Similar investigations were carried out on the Canada Land and Irrigation Company system and data obtained which should prove of value.

Canal carriage loss and reservoir loss investigations on the Lethbridge Northern Irrigation system were inaugurated, but while much useful information was obtained the results as a whole were not sufficiently conclusive to determine the desired factors with accuracy, owing to the peculiar situation which developed at the points selected. To secure definite results additional equipment on the canals will be necessary, together with the re-establishment of the stations in the vicinity of the reservoir.

An exhausive field and office investigation of the various factors in connection with the problem of dividing Battle creek in accordance with the ruling of the International Joint Commission was made.

The investigation as to snow conditions in the upper St. Mary river basin was again made in May. This stream is important from an international and irrigation standpoint and the survey was carried out jointly by officials of this service and the district engineer of the Montana Division of the United States Geological Survey.

Due no doubt to the fact that the precipitation has been normal or above normal in the past two years, there were fewer requests for stream-flow data in 1924-25 than in the immediately preceding seasons. The work entailed in supplying these data has not, however, been reduced as many of the requests now received necessitate the preparation of special information.

During the year hydrometric records obtained by the service were used by project managers in connection with the operation of the different irrigation systems of the Canadian Pacific Railway Company, the Alberta Railway and Irrigation Company project, the Lethbridge Northern Irrigation district, the Canada Land and Irrigation Company project, the New West irrigation district and the Calgary Power Company plants.

District of Manitoba

C. H. Attwood, District Chief Engineer

ORGANIZATION

During the fiscal year ended March 31, 1925, the regular stream measurement and power investigatory operations of the Dominion Water Power and Reclamation Service in Manitoba and adjacent districts have been continued.

The scope of the work covered by this district organization comprises the hydrometric power, storage and reclamation investigatory work in Manitoba and the Churchill river section of northeastern Saskatchewan, and also the hydrometric work in that portion of western Ontario inclusive of and lying to the west of the Nipigon river.

The local organization of the Dominion Water Power and Reclamation Service, headquartered at 231 Chambers of Commerce, Winnipeg, was organized in 1912 and the work then instituted has been carried on and extended from time to time. The duties of the engineers and hydrometric recorders consist of both field and office work, including surveys, investigations, and the preparation of data collected in report form, for submission to head office.

CO-OPERATION

The organization works in co-operation with several departments of the Federal Government, and the Power Commission and Reclamation Service of Manitoba.

HYDROMETRIC SURVEY

During the past year 101 regular and 17 miscellaneous stations have been maintained on lakes, rivers and tributaries in the following main watersheds: Nelson river, lake Winnipeg, Winnipeg river, Lake of the Woods, Rainy lake, English, Red, Assiniboine, Dauphin, and Saskatchewan rivers.

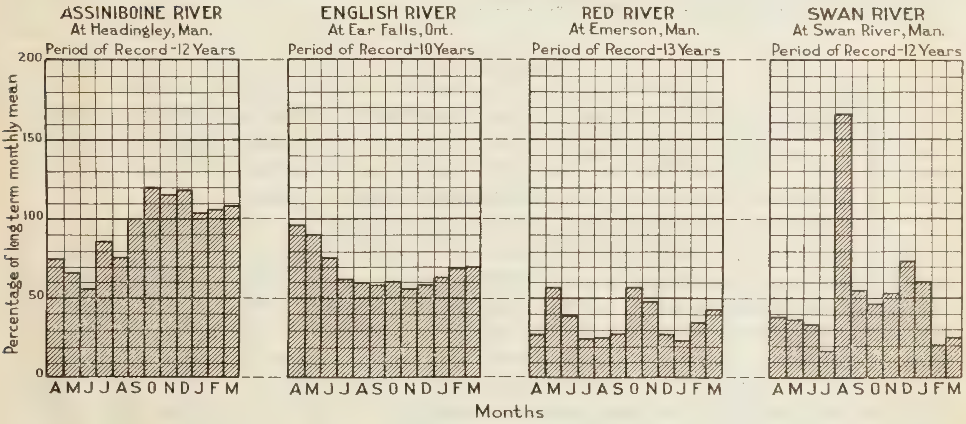
Of the above regular stations, there were maintained for power and storage 38 all year, 7 during open water and 6 miscellaneous; for drainage and reclamation throughout the year, 8 regular and 19 during open water with 11 miscellaneous. Five regular all year stations and 1 during open water were maintained for flood study. On international streams 14 all year and 6 open water regular stations were maintained, together with 4 miscellaneous. Five stations were maintained during open water only for water supply problems and for statistical purposes 5 all year stations. Ten meteorological stations were maintained continuously. In the above classification a number of stations have been maintained for more than one purpose.

Throughout the district the run-off for the past year has been low. In Manitoba on the Red river at Emerson and in Ontario on the English river at

PLATE 4

MEAN MONTHLY RUNOFF OF TYPICAL WATERSHEDS IN MANITOBA FOR YEAR 1924-25

RUNOFF SHOWN AS PERCENTAGE OF LONG TERM MONTHLY MEAN



Ear falls the minimum flow was the lowest for the period of record. Though the precipitation for the year was not much below the mean, that for the preceding 6 months was low, which accounts for the general light run-off.

In analysing the hydrological conditions in the province for the year, 4 streams have been selected as typical of conditions in their respective districts and the run-off and precipitation data have been analysed as shown on the accompanying chart (plate 4). As shown on the table giving an analysis of conditions of the storage period, *i.e.,* October 1, 1924, to March, 31, 1925, the precipitation up to March 1, was, with the exception of that on the watershed of the Assiniboine river, quite close to normal. During March, however, heavy snowfalls have occurred and with practically all of the winter's snowfall remaining there is every likelihood of high stages during the spring run-off. This applies particularly to the Assiniboine river, where, favourable climatic conditions obtain, such as a sudden change to warm days and nights, floods of the proportions of those in the springs of 1922 and 1923 may occur.

SPECIAL INVESTIGATIONS

During the year investigations were greatly curtailed, only the most urgent being undertaken. These are as follows:—

Ear Falls—Outlet of Lac Seul

Lac Seul being an important factor in the regulation and control of the English and Winnipeg rivers, it was decided to supplement the data available respecting the storage possibilities of the lake by securing more accurate data relating to foundation conditions.

In May last a party was sent to Ear falls to secure soundings to rock in the river bed and borings to rock on land. At Upper Ear falls a re-survey was made along the line of the proposed damsite and soundings in the river bed were obtained partly from canoe and partly from cable car, supplemented by intersections on the exposed rock at or near the surface. These soundings showed that the river bed along the site is all of solid granite gneiss comparatively smooth and regular. The depth to rock on land was obtained partly by digging test holes and partly by borings. Rock was found near the surface over a greater part of the site, but dipped down at the east end under a high covering bank of sand.

The information obtained during the survey has been used to compile new plans which have been used as a basis for new designs and estimates for a storage control dam at Upper Ear falls.

Canyon River

In May last, at the request of the Department of Indian Affairs, a survey was made of that portion of the Canyon river connecting Forest lake with Canyon lake, in the district of Kenora, Ontario, situated about 1½ miles south-west of McIntosh station on the Canadian National railway.

This site was investigated to ascertain the feasibility of developing a small water power at this point with sufficient capacity to meet the requirements of the proposed Indian Mission school to be built on the shore of Canyon lake adjoining the Power site. The natural fall in the river at the site is 12 feet in a distance of 330 feet and a study of the data obtained from the survey showed that by building a dam at the outlet of Forest lake and raising the waters of the lake 5 feet it would be quite feasible and economical to provide for a power development with an average annual capacity of 30 h.-p. The site of the proposed school is adapted for the requirements of the district and the power available in the stream at this point could be advantageously employed in lighting, pumping for water supply, sawing wood, etc.

Roseau River

In December, 1923, an application was received to develop 50 h.-p. on the Roseau river at Dominion city and this site was inspected in June, 1924. The inspection showed that a maximum head of 6 feet was about all that could be obtained without flooding over the river banks to adjoining property. Further, a study of the stream-flow records covering a period of 10 years showed a variation in discharge from 3 sec.-ft. to 2,800 sec.-ft. with a very low discharge throughout the winter months. The applicant was advised that the site was not one that could be recommended, as very little, if any, dependable power could be developed and that his power requirements could be met more satisfactorily and economically with a fuel plant.

Manitoba Power Commission

At the request of the Manitoba Power Commission an investigation was made of the power possibilities of the Birdtail creek at Birtle, the Shell river at Asessippi and the Assiniboine river at Millwood, together with an investigation of the storage possibilities of the Minnedosa River watershed.

The power possibilities of the Birdtail creek as a source of hydro-electric power to supply the town of Birtle were found to be entirely inadequate for the proper requirements of the town, due primarily to the extremely low flow which occurs at all seasons of the year other than during the spring run-off.

On the Assiniboine river at Millwood there is an old mill site and it was desired to ascertain the feasibility of developing power at this point for transmission to nearby towns and villages. A study of the stream-flow records and the physical conditions at the site plainly showed that a dependable supply of continuous power could not be obtained and that the scheme was not economically feasible.

The investigation of the Shell river at Asessippi revealed an interesting small water-power possibility which might be economically developed in conjunction with an auxiliary power plant if the market for power is available in the vicinity.

The storage investigation was in the Minnedosa river watershed and was made to determine to what extent the river could be regulated in connection with the hydro-electric power station at Minnedosa. The investigation showed that there are lakes available for storage reservoirs with sufficient capacity to maintain the flow of the river for 8 months in the year up to the requirements of the power station at Minnedosa.

The hydrometric records of the service have been freely drawn upon by federal, provincial and municipal bodies, and by railways, corporations and engineers in connection with the design and construction of bridges, trestles, culverts, drainage and power projects, and for legal evidence.

CONSTRUCTION

Lake of the Woods—Western Outlet

The agreement between the Department of the Interior and the Keewatin Power Company respecting the enlargement of the western outlet of the Lake of the Woods and the reconstruction of the Norman dam was signed on December 12, and upon the same date work was started on the construction of the upper cofferdam. The upper cofferdam, which is about 700 feet in length with a maximum depth of 36 feet, was completed on January 28, 1925, and the channel unwatered. The lower cofferdam, below the Norman dam, was commenced on January 5, and completed February 14. The installation of power plants, plant equipment, trestles, derricks, pumps, etc., was rapidly proceeded with and rock excavation was started during the first week in February. Concurrent with the channel excavation a steam shovel and derrick were also at work demolishing the rock-fill section of the Norman dam. In spite of snow and ice conditions prevailing the progress of the work to date is practically up to schedule.

The new channel was designed and staked out by the department's engineers, who also exercised direct supervision over the entire work, including the reconstruction of the Norman dam and power-house substructures.

City of Winnipeg Hydro-Electric System, Pointe du Bois

Late in the year the City of Winnipeg Hydro-Electric system installed Unit No. 12 in its hydro-electric plant at Pointe du Bois. The installation of this unit of 7,300 h.-p brings the total plant capacity to 74,400 h.-p.

In January and February, 1925, some 5,000 cubic yards of broken stone and crushed rock was placed on the upstream face of the rock-fill portion of the dam at Pointe du Bois in order to reduce the leakage through that portion of the dam. Flashboards were also placed on the spillway sections of the dam to increase the head and pondage facilities during the winter months.

Following a favourable vote by the ratepayers of the city of Winnipeg in November, 1923, the City of Winnipeg Hydro-Electric prepared designs and specifications and called for tenders for the construction of a central steam heating and stand-by plant and distribution system. This plant was constructed and placed in operation on October 8, 1924.

The central heating and stand-by plant contains coal handling and pulverizing equipment; three 1,100 b.h.p. vertical water-tube boilers with their auxiliaries and controls, feed pumps, etc.; two 7,500-kv.a. electric steam generators; one back pressure steam turbine direct connected to a 1,000-kw. alternator and two high-pressure steam turbines direct connected to two 5,000-kw. alternators with direct connected exciters mounted on the end of each generator. The central heating distribution system feeds part of the central business section of the city.

McIntosh Indian School

At the request of the Department of Indian Affairs plans were prepared for a hydro-electric development and a water supply and sewerage system for the Indian Residential School at McIntosh, Ont. Authorization for the construction of the dam and sewerage system was given in the late fall.

Though late in the season it was decided to proceed with construction in order that the spring run-off might be stored and sewerage facilities provided for the winter. With the poor transportation facilities available, together with winter conditions setting in earlier than usual, the necessary materials such as gravel, etc., could not be obtained until after freeze-up, and the work was carried on under extreme winter conditions. By February that portion of the dam across the river channel was constructed and as this would ensure the storing of sufficient of the spring run-off to provide a working head, it was decided to postpone further construction until after the spring break-up.

The sewerage system, consisting of septic tank and all necessary drains, was sufficiently completed to provide proper drainage for the winter.

District of Ontario

S. S. Scovil, District Chief Engineer

Organization

During the fiscal year ended March 31, 1925, the regular stream measurement and power investigatory operations of the Dominion Water Power and Reclamation Service in the province of Ontario have been continued consistent with the terms of the co-operative agreement of October 1, 1919, between the Department of the Interior and the Hydro-Electric Power Commission of Ontario.

The scope of the work covered by this district organization was enlarged during the year to include the hydrometric work of certain rivers in the Hudson Bay and Ottawa River drainage areas.

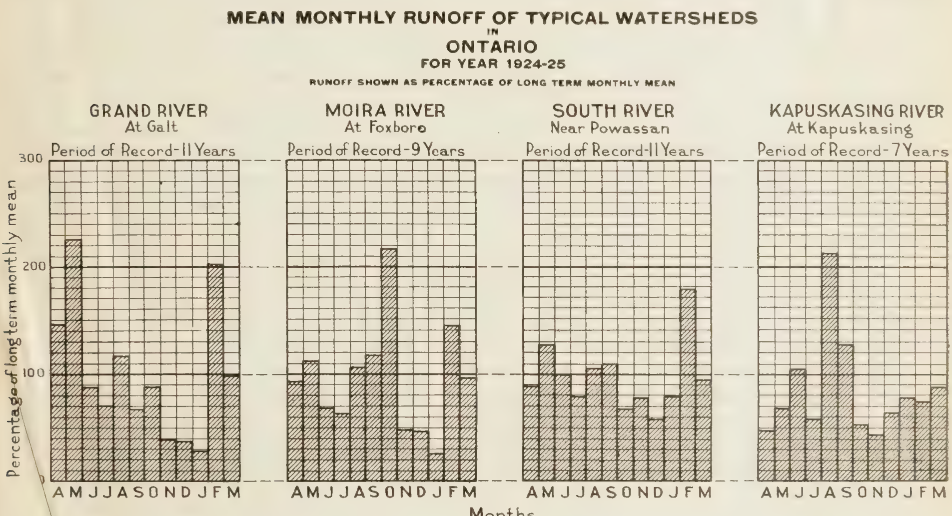
The work of the Ontario Hydrometric Survey was carried on under the direction of the district chief engineer with a head office in Ottawa at the corner of Metcalfe and Slater streets. Most of the field operations were carried

out by the field staff with an office in North Bay, Ont. The hydrometric investigations in that part of the province west of and including the Nipigon river were as in the previous year under the direction of the district office at Winnipeg.

CO-OPERATION

In pursuing the field and office investigations the closest co-operation has been maintained with the officers of the Hydro-Electric Power Commission of Ontario. Valuable assistance had also been given the engineers of the district by various persons and corporations interested in the securing of hydrological data. In particular, reference should be made to the co-operation carried on with the following companies: The Abitibi Power and Paper Company; the International Nickel Company of Canada, Limited; the Kaministiquia Power Company; the Mattagami Pulp and Paper Company; the Mississippi River Improvement Company; the Pigeon River Lumber Company; the Spanish River Pulp and Paper Company; the Spruce Falls Company; the Northern Ontario Power Company.

PLATE 5



HYDROMETRIC SURVEY

During the past year 63 regular stations were maintained on rivers and tributaries in the following main watersheds: Hudson Bay, Lake Superior, Lake Huron, Lake St. Clair, Lake Erie, Lake Ontario, and Ottawa river.

Of the above regular stations 54 were maintained throughout the year for power purposes. Five stations were maintained throughout the year, and 2 during spring run-off for flood study, 1 station for purposes of domestic water supply and 1 on an international power control problem.

With the exception of the southwestern district the average run-off throughout the province for the year was below normal. This is illustrated by the accompanying graph (plate 5) showing the monthly run-off as a percentage of the average flow over a number of years.

In the southwestern portion of the province, the records of the Grand river at Galt, which is typical of the general run-off conditions of this district, show an average run-off for the year of 0.920 sec.-ft per square mile, or 116 per cent of the mean for a period of 11 years. The flood inflows during April and May as well as the flow during February were above normal. During these three months the run-off ranged from 3.375 sec.-ft. per square mile in April or 145

per cent of the mean of record to a run-off of 1.091 sec.-ft. per square mile in February, or 201 per cent of the 11-year period. The mean run-off for May again reached a new high level for that month of 2.117 sec.-ft. per square mile. The remaining months were below normal, the minimum flow occurring during January with an average run-off of 0.149 sec.-ft. per square mile. The run-off for November reached a new minimum of 0.146 sec.-ft. per square mile, or 37 per cent of the mean for the previous years.

In the eastern portion of the province the mean run-off during the year was below normal, as is shown by the records of the typical station on the Moira river at Foxboro. The average flow for the year was 0.924 sec.-ft. per square mile, or 80 per cent of the mean for the period of record. The flood inflow during May, as well as the flow during August, September, October, and February were above normal. The remaining months were below normal, flow in January being only 24 per cent of the normal for that month and showed the greatest variation from normal.

In the North Bay district the mean run-off for the year was slightly below normal, as shown by the records of the typical station on the South river at Powassan, covering a period of 11 years. The average flow for the year was 1.034 sec.-ft. per square mile or 95 per cent of the mean run-off of 1.377 per square mile over the period of record. During the months of May, August, September, and February the mean run-off was above normal and ranged from 3.300 sec.-ft. per square mile in May to 0.616 sec.-ft. per square mile in August. The remaining months were below normal, the actual minimum flow occurring in January with a mean flow of 0.490 sec.-ft. per square mile, while the greatest deviation from normal occurred in December when the flow was only 58 per cent of the normal for that month.

In the northern portion of the province the mean run-off for the year was subnormal as shown by the records of the Kapuskasing river at Kapuskasing, covering a period of 8 years. The average run-off for the year was 0.510 sec.-ft. per square mile, or 68 per cent of the mean run-off of 0.755 sec.-ft. per square mile over the period of record. During the months of June, August, and September the average flow was above normal, and ranged from 1.320 sec.-ft. per square mile in June to 0.475 sec.-ft. per square mile in August. The mean for August reached a new high level for that month or 213 per cent of the mean. The remaining months were below normal, the actual minimum flow occurring during February with an average run-off of 0.143 sec.-ft. per square mile, while the greatest deviation from normal occurred in November when the flow was only 43 per cent of the normal for that month.

SPECIAL INVESTIGATIONS

The analysis of the water-power and storage resources of Ontario was continued during the year in close co-operation with the provincial authorities. In this connection the securing of more detailed surveys of the power reaches of certain of the rivers by the provincial officers has, in conjunction with more extensive records of stream-flow, permitted of a revision of earlier estimates of power resources and the compilation of more accurate data.

NIAGARA RIVER INVESTIGATION

Special study of the hydrology of the Niagara river was continued throughout the year, and very satisfactory results obtained in the investigation of discharge referred to the Buffalo breakwater gauge. Comparative tests between various types of current meters were carried on, and assurance given that the type of meter used in securing discharge measurements was entirly satisfactory and adequate for the work. The studies of river slopes and theeffect of diversions in governing pool levels have also been continued.

District of Quebec

L. G. Denis, District Chief Engineer

ORGANIZATION

In conformity with the co-operative agreement between the department and the Quebec Streams Commission, basic investigatory work on water-power and allied matters was continued in Quebec province by the Dominion Water Power and Reclamation Service throughout the year. This included the maintenance of various hydrometric stations in different parts of the province, a number of additional stations having been recently established where urgently required to satisfy request for information and to ensure the sound and intelligent development and utilization of the bountiful water-power potentialities of the province.

The work in Quebec is carried out under the direction of the district chief engineer's office at 201 Inspector street, Montreal, close relation being maintained in co-operating with the Quebec Streams Commission whose head office is also located in the same city.

CO-OPERATION

The investigations are carried out in well defined co-operation with the Quebec Streams Commission, but, in addition to this, many private organizations interested in the data secured lend most beneficial assistance by co-operating in the various activities of the service in Quebec. Among the latter organizations may be mentioned the Shawinigan Water and Power Company; Price Brothers, Limited; Laurentian Power Company; the Lower St. Lawrence Power Company.

HYDROMETRIC SURVEY

Including a number recently established, there are at present 50 regular hydrometric stations maintained. These stations are located in the following districts of the province: Lower Ottawa basin; Eastern Townships; north of the St. Lawrence from Montreal to below Quebec; Saguenay basin; Lower St. Lawrence. Of the above stations, 4 are at outlets of storage reservoirs, 4 others are operated mainly for flood observations, and 10 are in co-operation with private organizations. There are also 9 additional stations where gauge heights only are recorded.

In addition to the above, a special investigation of the Prairies river has necessitated the maintenance of 14 stations, where regular gauge-height records are being secured and the metering of the river at different open-water stages and under ice conditions.

Run-off conditions throughout the province during the past year were quite high, particularly during the usually low water periods. The spring of 1924 was marked by the absence of heavy floods, owing to the low temperatures which prevailed during the period of breakup, which consequently was gradual. This was followed by a period of fairly normal run-off while the unusually wet summer, followed by excessive autumn rains, caused very high run-offs throughout the province and unprecedented flood periods in certain portions, notably between Three Rivers and the Saguenay. These heavy autumn rains thoroughly saturated the ground before the freeze-up, resulting in the winter flow being at first above normal and later further increased by long periods of thaw and rain during the month of February.

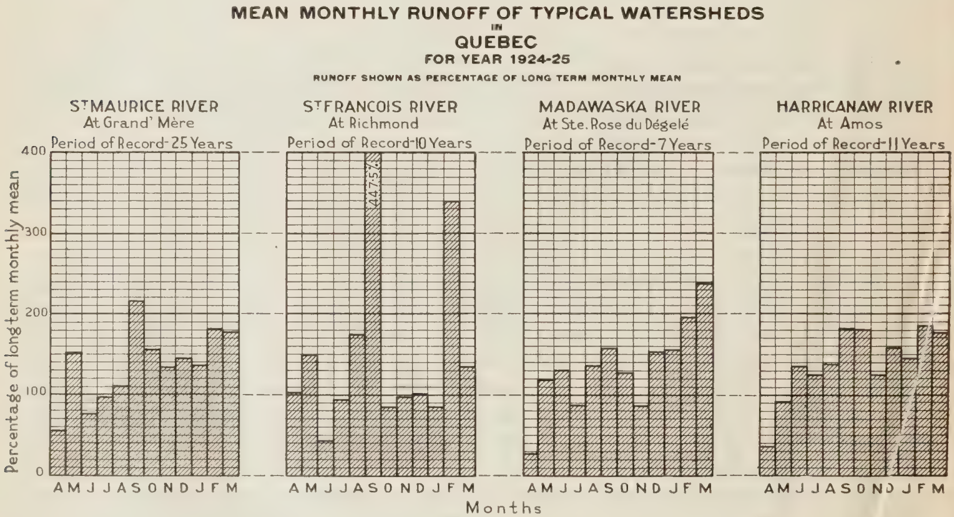
The above conditions are illustrated on plate 6, showing the monthly run-off as a percentage of the average flow over a number of years at 4 typical stations selected in different portions of the province. These typical stations are located at Grand'mere, on the St. Maurice river; at Richmond, on the St. François river; at Ste. Rose du Dégelé, on the Madawaska river; and at Amos, on the Harricanaw river.

In the portion of the province north of the middle St. Lawrence, the St. Maurice river, whose flow is regulated by the Gouin and other dams, had an average run-off 25 per cent above normal at Grand'mere. The run-off per square mile at flood was 10.72 sec.-ft. or 105 per cent of the previous maximum recorded, and during the low winter period 0.82 sec.-ft. or 403 per cent of the minimum previously recorded.

In the southern portion of the province, the St. Francois river, whose flow is regulated by the Allard dam, had an average run-off 25 per cent above normal at Richmond. The run-off per square mile at flood was 18.1 sec.-ft. or 121 per cent of the previous maximum, and the minimum was 0.40 sec.-ft. or 184 per cent of the minimum previously recorded.

Farther east, south of the St. Lawrence, the Madawaska river at Ste. Rose du Dégelé had an average run-off 14 per cent above normal. The run-off per square mile at flood was 10.30 sec.-ft. or 95.8 per cent of the previous maximum, and the minimum was 0.34 sec.-ft., or 660 per cent of the minimum previously estimated.

PLATE 6



SPECIAL INVESTIGATIONS

In the more northerly portion of the province, the Harricanaw river at Amos had an average run-off 24 per cent above normal. The run-off per square mile at flood was 4.61 sec.-ft., or 69.7 per cent of the previous maximum, and during the low winter period 0.27 sec.-ft. or 136 per cent of the minimum previously recorded.

Special efforts were made to secure and classify all additional water-power information published or otherwise available on the rivers of the province of Quebec, covering particularly all known, surveyed, or explored rivers of the province. These data are most useful in satisfying numerous requests for information along these lines, and summaries and tabular statements are being compiled from them for the Water Resources Inventory.

The investigation on the water levels and flow of the Prairies river, initiated at the beginning of 1924 in connection with a proposed power development, was continued throughout the year.

District of the Maritime Provinces

K. H. Smith, District Chief Engineer

ORGANIZATION

The agreement of July 1, 1919, between the Department of the Interior and the Governments of New Brunswick, Nova Scotia and Prince Edward Island, relating to the water-power resources of the three provinces, continued throughout the fiscal year ended March 31, 1925.

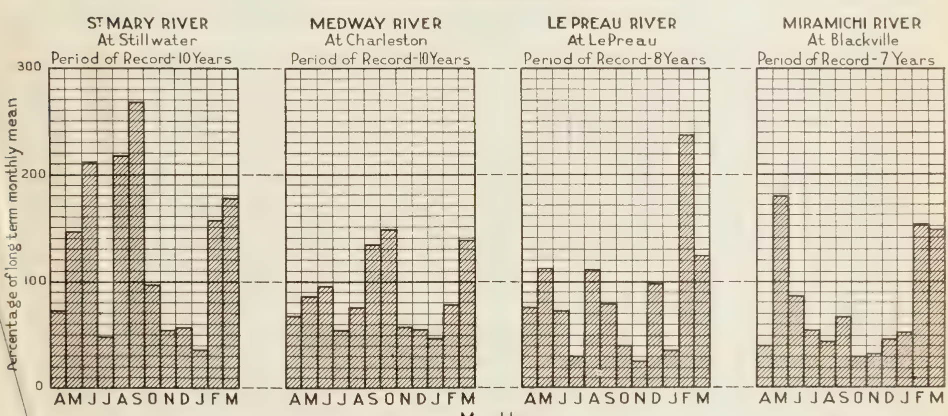
The headquarters of the Dominion Water Power and Reclamation Service in the Maritime Provinces are located at 193 Hollis street, Halifax, and from this centre work is carried in all three provinces. The two principal divisions of the work are: Hydrometric surveys for the systematic collection and analysis of all water-supply data and special investigations of important rivers in regard to their water-power potentialities.

HYDROMETRIC SURVEY

During the year 34 gauging stations were maintained—21 in Nova Scotia, 10 in New Brunswick, and 3 in Prince Edward Island. Twelve of the rivers

MEAN MONTHLY RUNOFF OF TYPICAL WATERSHEDS IN THE MARITIME PROVINCES FOR YEAR 1924-25 — Plate 7

RUNOFF SHOWN AS PERCENTAGE OF LONG TERM MONTHLY MEAN



gauged in Nova Scotia are important power streams, and the remaining 9 are representative streams on which records are desired for statistical purposes to serve as the basis for estimates on other streams. The ten rivers in New Brunswick are, with the exception of the Kennebecasis, potential sources of power, and, in addition, are so distributed as to give added value to the records for comparative estimates of flow and power on other streams. In Prince Edward Island there are no large power sites and the three gauging stations maintained are valuable for statistical purposes in estimates of water supply.

Owing to wide variation in climatic and other factors affecting run-off in different portions of the Maritime Provinces, average figures for the whole district have little meaning. In general the run-off was above normal in the eastern portion and below normal in the western. On the St. Mary river the average run-off for the year was 2.97 sec.-ft. per square mile, or 112 per cent of the long-term mean. The same quantities for the 3 other typical streams were: Medway, 2.20 sec.-ft., or 83 per cent; Lepreau, 2.71 sec.-ft., or 85 per cent; Miramichi, 1.82 sec.-ft., or 90 per cent (see plate 7). Extremes of high-water more severe than those previously recorded occurred only in the northern portion of Nova Scotia. On October 1, 1924, a rain storm of great local severity gave record flood flows in this district. The observed streams

affected were the Great Village, Economy, Wallace, Salmon, and South rivers where floods of 108, 80, 66, 76, and 50 sec.-ft. per square mile, respectively, were recorded. No record minimums occurred anywhere in the district, but a feature of the runoff-year was the extreme cold dry winter in northern New Bunswick, which, coming after a comparatively dry summer and fall, caused low winter run-off, and lengthened an already long season of subnormal flow in that district. This is shown on the graph for the Miramichi river, where the run-off is below normal for the eight consecutive months from June to February.

Over the greater port of the district the snow storage was light during the winter of 1924-25, and the spring break-up which set in early was accompanied by much lower rates of run-off than usual.

SPECIAL INVESTIGATIONS

At Grand Falls in New Brunswick the contour of the flowage from the proposed dam of the New Brunswick Electric Power Commission was continued for about 10 miles above the point reached by the survey of 1923. The data obtained from this survey have been used by the commission to determine the pondage and the acreage of flood damage.

The tidal power scheme of J. R. Turnbull for the Petitcodiac and Memramcook estuaries became a live question early in 1924, and extensive boring operations were carried on by the Department of Public Works co-operating with the Water Power and Reclamation Service to determine the foundation conditions at the sites of the proposed structures.

The contemplated development of the Bathurst Company, Limited, of further hydro-electric power on the Nipisiguit river required a very careful computation of all run-off records available for the river. By means of records obtained at the service gauging stations, and extended computations from the power-house records of the Great Falls power plant, data were submitted to the company's consulting engineers, which served as the basis for their findings on this project.

In further connection with the plans of development at Grand Falls, some attention was given the question of International Water Rights on the St. John drainage system, and the service was represented at the hearing before the International Joint Commission.

In Nova Scotia several investigations were carried out at the request of the Minister under the Nova Scotia Water Act to assist the Provincial Government in the settlement of disputes between rival operators on several streams. Chief among these were: The Senora Timber versus the Sherbrooke Lumber Company on the St. Mary river; the Caledonia Mills versus Walter McNeil on the Medway river; and the Bear river arbitration case.

A number of small streams near the towns of Canso and Antigonish were investigated and reported upon as possible sources of municipal power supply for the two towns named.

Considerable attention and study was given to problems arising from various undertakings and projects of the Nova Scotia Power Commission.

In the way of routine power investigations, Evans brook near Annapolis was completed and some further surveying carried on at Fales river and Ingram river to complete the data for those streams.

A great many requests for information were received from various sources. In most cases such inquiries could be met by reference to filed data, and in others special field work was performed if time was available.

The co-operative investigation of water resources in the Maritime Provinces has led to the development of government-owned plants, of which 7 are now operating. These have a combined capacity of 34,000 h.-p. and represent an investment of nearly $7,000,000. In addition to these a number of municipal and private water-power enterprises have been carried out, based upon the records and data supplied by the Dominion Water Power and Reclamation Service.

PART II

RECLAMATION

IRRIGATION

J. S. Tempest, Commissioner of Irrigation

Following the procedure of the past few years, only a summary of the reports prepared by the various officers of the service is being submitted. The original reports are on file in the offices of the Dominion Water Power and Reclamation Service at Ottawa and Calgary and further information can be obtained by those interested in any particular subject.

General

In addition to the general administration of the Irrigation Act, the work undertaken during the past year may be classified as follows:—

(*a*) Giving engineering assistance and advice to irrigation districts and to individual irrigators.
(*b*) Surveying of possible reservoir sites.
(*c*) Investigating and studying seepage and alkali problems.
(*d*) Making special field investigations and reports in connection with the drought areas in southeastern Alberta.
(*e*) Classifying irrigable lands in connection with new irrigation districts and the reclassification of irrigable areas where farm units have been subdivided.
(*f*) Continuing duty of water investigations.

Careful field inspections have been regularly made during the past few years in connection with the seepage problem from the larger irrigation canals. As this is a problem of vital concern to all operating irrigation companies and districts, the studies which are being kept up to date are much appreciated by those directly concerned, and the co-operation and advice of departmental engineers is regularly sought. One of the larger companies is undertaking some important experiments with a view to reclaiming considerable areas of land which have become seriously damaged by the rise of alkali, and in this connection a helpful spirit of co-operation has been shown which will make it possible to record the success attained. There is a continuous demand for classification and reclassification of irrigable lands, both from irrigation companies and individuals owning irrigable land. Such a reclassification is required whenever a farm unit is subdivided into smaller and often more economic areas. It is frequently requested by water users, whose lands are held under agreement for sale with the large irrigation companies, in connection with damaged areas due either to seepage or the movement of alkali.

During the year, with the exception of a strip of country extending from 50 to 60 miles eastward of the foothills of the Rocky mountains where sufficient rain-fall was received, precipitation in the semi-arid belt of Alberta and Saskatchewan has been below normal. Considerable crop losses were sustained in this sub-normal area.

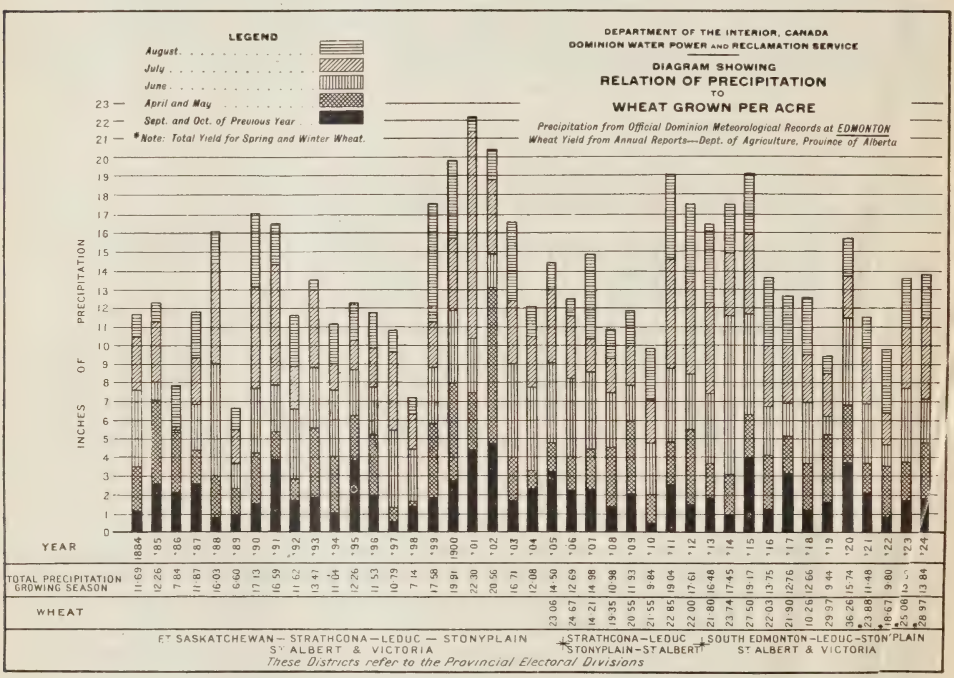
The charts illustrating the relation of precipitation to the wheat grown per acre have been brought up to date and now represent a 40-year period of

records in so far as the precipitation is concerned. It should be noted that the precipitation received during September and October of the previous year, which would be stored and available for germinating the following year's crop, is included in the total amount considered in producing the crop.

Water Administration

During the calendar year 1924, 96 applications, which included a large proportion of industrial schemes in connection with railway development, were filed for the right to use water under the Irrigation Act. There were, at the end of the year, 918 licenses in good standing, 10 temporary permits, 337 authorizations and 246 schemes under investigation.

Plate 8



As additional information becomes available with regard to run-off and the beneficial use of water in different localities, old licenses which were issued before the actual conditions were of record, are being revised. Detailed information is continually being collected in order that each case may be considered on its merits, and whenever possible, adjustments are made to suit the requirements of the licencee with due regard to other interests which may be affected.

Inspection Work

The work in the two provinces, Alberta and Saskatchewan, which is under the direct supervision of an office engineer, was carried out by 4 field engineers, instead of 5 as in previous years, necessitating a considerable adjustment in district boundaries. The inspection districts as operated for the year 1924-25 and the number of inspections carried out in each are tabulated below:—

District	Number of inspections made during season
East Cypress hills	69
West Cypress hills	72
Macleod	89
Alberta and Saskatchewan—special inspections	80

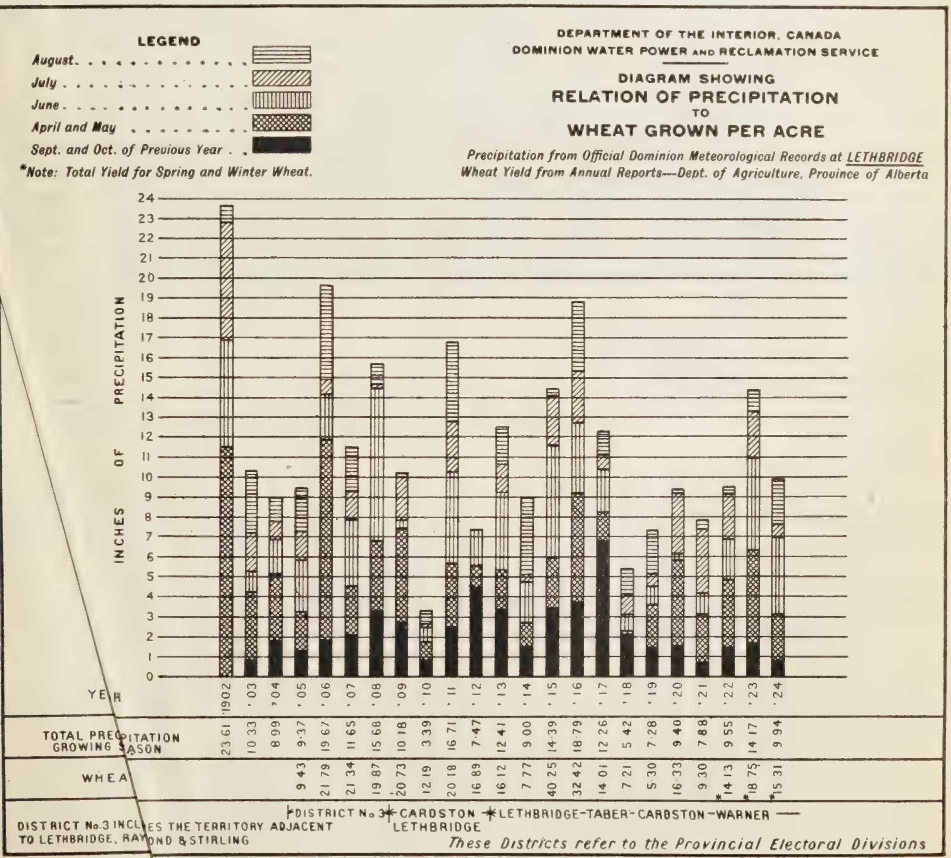
The inspection work has again fallen somewhat below normal, the total number of inspections made decreasing from 348 in 1923 to 310 in 1924. Owing to the reduction in field staff the average number of inspections per engineer somewhat increased in 1924. In addition to their inspection duties, the officers in charge of districts carried out a certain amount of hydrometric work.

The Macleod district showed the greatest amount of irrigation development in so far as privately-owned projects are concerned. In this district during the season several schemes were completed and recommended for licence, and at the end of the season there were 84 authorized schemes still in course of construction.

East Cypress Hills District.—This district comprised all that portion of the province of Saskatchewan lying south of tp. 25.

The engineer in charge of this district was made responsible for a certain amount of hydrometric work in addition to his routine inspection duties. He

PLATE 9



also made a number of right-of-way surveys in Alberta and Saskatchewan. He carried out the necessary work in connection with the operation of the Maple Creek test plots at odd times during the season.

The period March 31 to April 16 was spent on early spring run-off work near Maple Creek. The regular field season commenced May 2, and continued until October 25. After his return to Calgary this engineer was detailed to assist on reclassification work in the United Irrigation district and spent a further period in the field extending from October 29 to November 22.

During the season 66 inspections, 16 surveys and 45 gaugings were made. Three additional inspections in this district were carried out by the drainage inspector for the province of Saskatchewan.

Everything is being done to make known to agriculturalists of the districts what can be accomplished by systematic irrigation under the conditions prevailing locally.

The bulk of the irrigable land is in wild hay, which forms the basis of the feed supply of many head of stock. With the improvement of the stock industry there will be more incentive to the development and construction of irrigation works.

West Cypress Hills District.—This district lies in the southeast corner of the province of Alberta, bounded on the north by tp. 19 and on the west by rge. 17, W. 4th mer.

During the season, which extended from May 2, to December 10, the inspector in this district carried out the hydrometric work, when 69 gaugings were made, as well as his ordinary routine work which consisted of 72 inspections and 21 surveys. In addition he spent 11 days in June giving engineering assistance to farmers in the Lethbridge Northern irrigation district. For 35 days in October and November he was engaged on land classification work in the United irrigation district.

The exceptionally small amount of snowfall in this district during the winter of 1923-24 resulted in an abnormally low run-off last spring. The precipitation until late in the season was very meagre. As a result no irrigation was practised on some of the streams, while on others there was an insufficiency of water to satisfy the requirement of license No. 1. The pumping schemes, of which there are at present 74 in the district, had an ample supply of water throughout the season. Many of these schemes situated along the South Saskatchewan river use natural gas for fuel, which is obtained from wells 600 to 900 feet in depth.

The raising of feed for stock is the most important branch of agriculture at present carried on.

MacLeod District.—This district lies in the southwest corner of the province of Alberta, bounded on the north by tp. 19 and on the east by rge. 16, W. o the 4th mer.

The engineer in charge of the district, in addition to his routine inspection duties, took over a portion of the hydrometric work of the district. The field season covered the period April 24 to November 30. The first part of the season until May 13, was spent on hydrometric work near Macleod. Eight days in June were devoted to rendering engineering assistance to farmers in the Lethbridge Northern irrigation districts. During the season 89 inspections, 12 surveys, and 84 gaugings were made. A number of these discharge measurements were taken at selected points on the Lethbridge Northern irrigation district's main canal at regular intervals throughout the season in connection with the study of seepage losses on this canal.

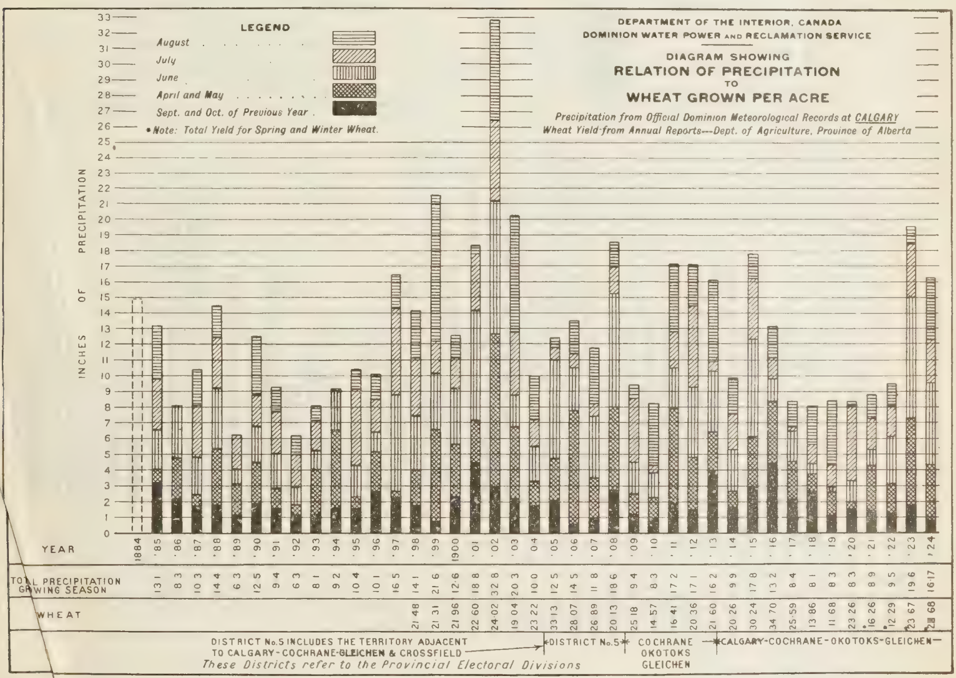
The total precipitation at Hillspring from May 1 to September 30 was 15.28 inches. In the neighbourhood of High River, Nanton, Claresholm, and south and west of Macleod, wheat crops were good. Along the foothills country in the western half of the district good yields were obtained on many small irrigation schemes, resulting in large fodder crops for winter feed.

During the year 10 irrigation schemes were completed and recommended for license, and at the end of the season there were 84 schemes still in course of construction.

Alberta and Saskatchewan Special Inspections District.—For the 1924 field season this district comprised all of the province of Alberta north of tp. 18 and all of the province of Saskatchewan north of tp. 24. Any inspection work in this large territory which could be more economically carried out by the drainage inspectors was handed over to them. The Saskatchewan drainage inspector made 1 inspection of this kind and the Alberta drainage inspector 15.

Several inspections around Calgary were carried out in April and the first week in May as weather conditions permitted. From May 13 to June 1 the inspecting engineer was engaged in giving assistance to farmers in the New West irrigation district. The inspection season proper started on June 10 and finished

PLATE 10



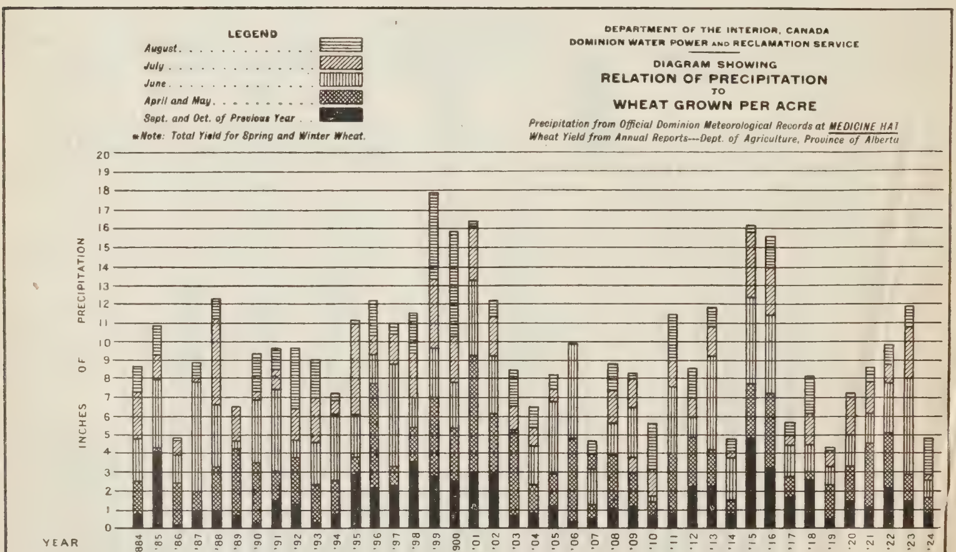
October 20. During the latter part of October and on into November when weather conditions permitted a number of inspections were made of irrigation schemes in the foothills south and west of Calgary. During the season the engineer in charge made 64 inspections, 14 surveys, and 40 gaugings.

On account of the very small spring run-off in 1923 and its almost total absence in 1924, very few irrigation applications depending on such a supply have been received during the year. Applications for pumping schemes have also decreased.

Drought Area Investigation.—It has long been recognized that throughout extensive areas in southern Alberta the precipitation is insufficient for the growth of crops. Extensive irrigation surveys have been made with a view to the reclamation of these areas and, while it is economically feasible to irrigate considerable areas, by far the largest percentage cannot be thus reclaimed and it is now generally conceded that these lands are more suitable for ranching than for farming purposes.

In order to arrive at a better understanding of what is required to solve these dry land problems generally, a large area between the Red Deer and South Saskatchewan rivers, lying to the east of the Canadian Pacific Railway tract (eastern section), has been investigated, primarily having regard to the available water supply and the suitability of the lands for ranching. It is considered that conditions with regard to topography and water supply throughout a large portion of the area are satisfactory for ranching purposes and that by taking proper remedial measures in regard to regrassing the area it could be converted into a very desirable ranching country and utilized as community ranches in providing summer range for the stock of farmers on adjacent irrigation projects, while crops are grown on the irrigable lands for winter feed.

PLATE 11



YEAR	1884	'85	'86	'87	'88	'89	'90	'91	'92	'93	'94	'95	'96	'97	'98	'99	1900	'01	'02	'03	'04
TOTAL PRECIPITATION GROWING SEASON	8·49	10·95	4·77	8·95	12·27	6·53	9·45	9·65	9·63	9·07	7·27	11·21	12·02	10·94	11·49	17·96	15·91	16·43	12·15	8·44	6·48
WHEAT																					

YEAR	'05	'06	'07	'08	'09	'10	'11	'12	'13	'14	'15	'16	'17	'18	'19	'20	'21	'22	'23	'24
TOTAL PRECIPITATION GROWING SEASON	8·15	9·78	4·67	8·89	8·26	5·40	11·42	8·52	11·75	4·76	16·05	15·57	5·76	8·03	4·24	7·23	8·55	9·81	11·59	4·7[illegible]
WHEAT	15·87	18·53	11·17	5·30	22·80	7·02	18·23	15·58	11·40	5·08	40·50	24·57	17·02	3·09	3·14	8·81	8·82	*9·78	*11·48	*8·54

DISTRICT No. 6 INCLUDES THE TERRITORY ADJACENT TO C.P.R. FROM WALSH TO LANGEVIN & NTH TO TOWNSHIP 38 — DISTRICT No. 6 — MEDICINE HAT — MEDICINE HAT — REDCLIFF —
These Districts refer to the Provincial Electoral Divisions

Watermasters.—The three inspecting engineers in charge of the southernmost districts, namely: the East Cypress Hills, West Cypress Hills, and Macleod districts, operating under their watermaster's warrants encountered no difficulties in settling in an amicable manner the few complaints which arose.

Domestic Water Supplies.—Settlers find it necessary in parts of the country where there are no perennial streams, and where there are no sloughs or lakes of a dependable nature, to ensure themselves a satisfactory water supply for domestic and stock watering purposes by artificial means. These generally take the form of earthen dams in coulees and other natural depressions, for the purpose of storing the water which from time to time comes down these watercourses, from melting snow in the spring or after heavy rains. The quantity of water thus conserved is generally very small and surplus run-off is usually taken care of by means of an excavated spillway around the dam. In the case of any unregistered schemes of this nature which come under notice the owners are

advised to protect their own interests by submitting formal applications for the maintenance of their works. The small expenditure thus involved is considered well spent in the protection afforded.

Municipal Water Consumption Data.—The collection of these data have been continued throughout the past year. The department is indebted to the various towns and cities for their co-operation in furnishing these data. The completed records are submitted in the tables appended.

Cities and Towns in the Province of Alberta—Daily Record of Water Consumption in Imperial Gallons for the Year 1924

Month	Athabaska						Bassano					
	Population 450						Population 1,000					
	Daily Average for the month	Per Head for domestic purposes	Per Head for industrial purposes	Per Head for other purposes	Per Head for all purposes	Unaccounted for	Daily Average for the month	Per Head for domestic purposes	Per Head for industrial purposes	Per Head for other purposes	Per Head for all purposes	Unaccounted for
January	10,300	20·7	....	2·1	22·8	....	149·000	....	....	....	149·0	....
February	9,800	21·8	....	....	21·8	....	142·400	....	....	....	142·4	....
March	6,900	15·2	....	....	15·2	....	132,300	....	....	....	132·3	....
April	10,100	22·4	....	....	22·4	....	143,200	....	....	....	143·2	....
May	6,200	13·7	....	....	13·7	....	178,500	....	....	....	178·5	....
June	9,900	22·0	....	....	22·0	....	183,200	....	....	....	183·2	....
July	9,800	21·7	....	....	21·7	....	219,700	....	....	....	219·7	....
August	6,900	15·4	....	....	15·4	....	211,300	....	....	....	211·3	....
September	6,200	13·7	....	....	13·7	....	184,300	....	....	....	184·3	....
October	6,500	14·4	....	....	14·4	....	210,200	....	....	....	210·2	....
November	10,000	22·2	....	....	22·2	....	183,500	....	....	....	183·5	....
December	6,500	14·5	....	....	14·5	....	181,400	....	....	....	181·4	....
Average for the year	8,200	18·0	....	0·2	18·2	....	176,800	....	....	....	176·8	....

Month	Edmonton						Lethbridge					
	Population 60,000						Population 11,000					
	Daily Average for the month	Per Head for domestic purposes	Per Head for industrial purposes	Per Head for other purposes	Per Head for all purposes	Unaccounted for	Daily Average for the month	Per Head for domestic purposes	Per Head for industrial purposes	Per Head for other purposes	Per Head for all purposes	Unaccounted for
January	4,989,000	48·2	20·8	14·1	83·1	....	1,458,000	94·9	37·6	0·0	132·5	
February	4,836,000	46·7	20·1	13·7	80·6	....	1,324,000	83·2	37·1	0·0	120·3	....
March	4,891,000	45·9	21·2	14·4	81·5	....	1,210,000	75·2	34·8	0·0	110·0	....
April	4,887,000	47·2	20·4	13·8	81·4	....	1,168,000	71·5	31·6	3·1	106·2	....
May	6,890,000	66·6	28·7	19·5	114·8	....	1,556,000	102·3	38·0	1·1	141·4	....
June	6,588,000	63·7	27·4	18·7	109·8	....	1,326,000	91·9	28·3	0·4	120·6	....
July	6,587,000	68·6	27·4	13·7	109·8	....	1,941,000	129·3	37·2	10·0	176·5	....
August	5,708,000	55·2	23·8	16·2	95·1	....	1,337,000	86·7	34·2	0·7	121·6	....
September	5,614,000	54·3	23·4	15·9	93·5	....	1,399,000	87·6	38·3	1·2	127·1	....
October	5,321,000	51·4	22·1	15·1	88·5	....	1,337,000	80·2	41·3	0·0	121·5	....
November	5,595,000	54·1	23·3	15·9	93·2	....	1,372,000	79·4	45·3	0·0	124·7	....
December	[illegible],948,100	57·5	24·8	16·8	99·1	....	1,339,000	83·0	38·7	0·0	121·7	....
Average for the year	5,[illegible]58,000	55·0	23·7	15·7	94·4	....	1,397,300	88·8	36·8	1·4	127·0	....

Cities and Towns in the Province of Alberta—Daily Record of Water Consumption in Imperial Gallons for the Year 1924—Con.

Month	Medicine Hat						Redcliff					
	Population 10,000						Population 1,100					
	Daily Average for the month	Per Head for domestic purposes	Per Head for industrial purposes	Per Head for other purposes	Per Head for all purposes	Unaccounted for	Daily Average for the month	Per Head for domestic purposes	Per Head for industrial purposes	Per Head for other purposes	Per Head for all purposes	Unaccounted for
January	2,025,000	....	....	....	202·5	....	122,200	103·3	7·8	....	111·1	....
February	1,941,000	....	....	....	194·1	....	91,500	74·8	8·4	....	83·2	....
March	1,773,000	....	....	....	177·3	....	123,400	104·4	7·8	....	112·2	....
April	1,869,000	....	....	....	186·9	....	123,800	104·4	8·1	....	112·5	....
May	2,492,000	....	....	....	249·2	....	196,700	170·3	8·5	....	178·8	....
June	2,575,000	....	....	....	257·5	....	191,200	165·1	8·7	....	173·8	....
July	3,647,000	....	....	....	364·7	....	294,700	258·9	9·0	....	267·9	....
August	2,793,000	....	....	....	279·3	....	222,500	193·7	8·6	....	202·3	....
September	2,261,000	....	....	....	226·1	....	189,400	163·5	8·7	....	172·2	....
October	1,898,000	....	....	....	189·8	....	100,400	82·9	8·4	....	91·3	....
November	1,706,000	....	....	....	170·6	....	125,500	105·6	8·5	....	114·1	....
December	1,684,000	....	....	....	168·4	....	132,900	112·7	8·1	....	120·8	....
Average for the year	2,222,000	....	....	....	222·2	....	159,500	136·6	8·4	....	145·0	....

Cities and Towns in the Province of Saskatchewan—Daily Record of Water Consumption in Imperial Gallons for the Year 1924

Month	Estevan						Kindersley					
	Population 2,300						Population 1,000					
	Daily Average for the month	Per Head for domestic purposes	Per Head for industrial purposes	Per Head for other purposes	Per Head for all purposes	Unaccounted for	Daily Average for the month	Per Head for domestic purposes	Per Head for industrial purposes	Per Head for other purposes	Per Head for all purposes	Unaccounted for
January	46,500				20·2	....	10,220	....	....	....	10·2	....
February	41,800	8·5	6·9	3·5	18·2	....	9,200	....	....	....	9·2	....
March	42,400				18·4	....	8,600	....	....	....	8·6	....
April	39,900				17·3	....	9,600	....	....	....	9·6	....
May	48,200	9·8	4·9	4·8	21·0	....	10,200	....	....	....	10·2	....
June	46,200				20·1	....	15,500	....	....	....	15·5	....
July	58,900				25·6	....	18,300	....	....	....	18·3	....
August	33,700	10·5	5·2	3·1	14·7	....	10,700	....	....	....	10·7	....
September	37,100				16·1	....	10,300	....	....	....	10·3	....
October	32,300				14·0	....	8,800	....	....	....	8·8	....
November	34,500	7·8	7·5	–	15·0	....	8,400	....	....	....	8·4	....
December	39,000				17·0	....	12,300	....	....	....	12·3	....
Average for the year	41,800	9·2	6·1	2·9	18·2	....	11,000	....	....	....	11·0	....

Month	Moose Jaw						Weyburn					
	Population 20,000						Population 3,200					
	Daily Average for the month	Per Head for domestic purposes	Per Head for industrial purposes	Per Head for other purposes	Per Head for all purposes	Unaccounted for	Daily Average for the month	Per Head for domestic purposes	Per Head for industrial purposes	Per Head for other purposes	Per Head for all purposes	Unaccounted for
January	850,000	34·9	7·6	....	42·5	....	257,800	....	....	....	80·6	....
February	867,000	34·8	8·6	....	43·4	....	234,600	....	....	....	73·3	....
March	892,000	36·5	8·0	....	44·5	....	228,200	....	....	....	71·3	....
April	881,000	36·1	8·0	....	44·1	....	228,700	....	....	....	71·5	....
May	894,000	36·5	8·2	....	44·7	....	241,100	....	....	....	75·3	....
June	945,000	37·0	9·3	....	46·3	....	253,500	....	....	....	79·2	....
July	1,040,000	44·0	8·0	....	52·0	....	262,300	....	....	....	82·0	....
August	937,000	38·8	8·0	....	46·8	....	258,200	....	....	....	80·7	....
September	857,000	35·1	7·7	....	42·8	....	243,000	....	....	....	75·9	....
October	830,000	35·3	6·2	....	41·5	....	258,200	....	....	....	80·7	....
November	843,000	33·4	8·8	....	42·2	....	263,400	....	....	....	82·3	....
December	853,000	35·7	7·4	....	43·1	....	244,200	....	....	....	76·3	....
Average for the year	892,000	36·5	8·0	....	44·5	....	247,800	....	....	....	77·4	....

Cities and Towns in the Province of Saskatchewan—Daily Record of Water Consumption in Imperial Gallon for the Year 1924—Con.

Month	North Battleford						Kamsack					
	Population 4,100						Population 375*					
	Daily Average for the month	Per Head for domestic purposes	Per Head for industrial purposes	Per Head for other purposes	Per Head for all purposes	Unaccounted for	Daily Average for the month	Per Head for domestic purposes	Per Head for industrial purposes	Per Head for other purposes	Per Head for all purposes	Unaccounted for
January.....	123,500	9·8	1·0	5·1	30·1	14·2	133,200	21·1	212·5	5·3	355·2	116·3
February...	123,000	10·3	1·2	4·2	30·0	14·2	122,500	23·4	215·5	14·5	326·7	73·3
March......	137,100	9·2	1·5	4·4	33·4	18·4	90·200	22·2	187·7	5·4	240·6	25·3
April.......	126,900	7·0	1·5	7·5	31·0	15·0	123·100	21·3	108·1	5·4	328·2	193·4
May........	136,200	10·0	1·7	3·5	33·2	18·0	164,000	33·4	265·7	5·7	437·3	132·5
June........	172,200	14·4	2·9	4·0	42·0	20·7	179·800	23·4	101·6	2·0	479·6	352·6
July........	186,100	12·6	7·2	2·5	45·3	23·0	176,400	22·2	119·7	3·5	470·4	325·0
August......	145,200	11·2	2·8	0·8	35·4	20·6	158,900	23·8	187·7	1·9	423·7	210·3
September..	127,100	12·5	2·3	0·8	31·0	15·3	145,100	23·5	188·4	7·2	386·9	167·8
October.....	134,400	9·2	2·1	4·4	32·7	17·1	170,100	31·6	246·1	12·5	435·7	163·5
November..	114·300	12·2	2·0	4·8	27·9	8·8	201,900	23·4	321·8	6·4	538·3	186·7
December..	119,800	10·8	1·8	2·8	29·2	13·8	108,700	27·7	178·1	6·4	289·9	77·7
Average for the year..	137,200	10·8	2·3	3·7	33·4	16·6	147,800	24·8	194·4	6·3	394·1	168·7

*Only 78 houses supplied or approximately 375 people. This is figure used in computations although total population is about 2,000.

Month	Regina						Saskatoon					
	Population 35,000						Population 27,000					
	Daily Average for the month	Per Head for domestic purposes	Per Head for industrial purposes	Per Head for other purposes	Per Head for all purposes	Unaccounted for	Daily Average for the month	Per Head for domestic purposes	Per Head for industrial purposes	Per Head for other purposes	Per Head for all purposes	Unaccounted for *
January.....	2,712,300	61·6	13·8	1·5	77·5	0·7	1,779,400				65·9	....
February...	2,795,300	65·9	12·1	1·9	79·9	....	1,683,400	26·4	19·7	0·4	62·3	16·1
March......	2,802,700	63·6	13·1	1·5	80·0	1·8	1,611,000				59·7	....
April.......	2,761,200	62·7	14·4	1·0	78·9	0·7	1,603,000				59·4	....
May........	2,688,800	60·3	15·3	1·2	76·8	....	1,898,100	26·5	17·8	2·7	70·3	22·6
June........	2,612,600	57·2	16·2	1·1	74·6	....	2,137,300				69·2	....
July........	2,831,700	71·7	7·5	1·8	80·9	....	2,441,900				90·4	....
August......	2,674,800	69·3	5·7	1·5	76·4	....	1,854,800	31·4	18·7	5·2	68·7	21·7
September..	2,756,200	69·3	7·8	1·6	78·7	....	1,941,700				71·9	....
October.....	2,580,400	68·3	4·1	1·3	73·7	....	1,820,200				67·4	....
November..	2,456,600	65·0	3·5	1·7	70·2	....	1,886,800	27·5	20·6	1·3	70·0	18·6
December..	2,539,600	66·0	2·9	2·0	72·6	1·7	1,797,700				66·6	....
Average for the year..	2,684,400	65·1	9·7	1·5	76·7	0·4	1,871,300	27·9	19·2	2·4	69·3	19·8

*Includes Town of Sutherland.

Month	Prince Albert					
	Population					
	Daily Average for the month	Per Head for domestic purposes	Per Head for industrial purposes	Per Head for other purposes	Per Head for all purposes	Unaccounted for
January..........	446,100	23·9	26·5	0·6	59·5	8·5
February..........	424,300	23·1	27·9	0·4	56·6	5·2
March..........	414,800	20·8	20·9	0·8	55·3	12·8
April..........	408,100	23·4	22·8	0·5	54·4	7·7
May..........	446,000	21·8	24·7	3·4	59·5	9·6
June..........	510,700	25·7	26·8	1·6	68·1	14·0
July..........	604,000	27·4	35·1	2·4	80·5	15·6
August..........	499,600	27·5	34·6	1·8	66·6	2·7
September..........	473,900	23·7	28·3	1·1	63·2	10·1
October..........	485,100	23·3	26·5	1·1	64·7	13·8
November..........	574,800	25·2	36·6	1·5	76·6	13·3
December..........	603,900	24·7	34·0	2·8	80·5	19·0
Average for the year..........	490,900	24·2	28·7	1·5	65·4	11·0

Cities and Towns in the Province of Alberta—Record of Average Daily Water Consumption in Imperial Gallons for Years 1915-16-17-18-19-20-21-22-23-24.

Year	Per Head Domestic	Per Head Industrial	Per Head other Purposes	Per Head all Purposes	Unaccounted for	Per Head Domestic	Per Head Industrial	Per Head other Purposes	Per Head all Purposes	Unaccounted for
	Edmonton					Lethbridge				
1915	46·0	31·0	3·0	80·0	....	81·4	32·2	1·5	115·1	....
1916	52·5	20·7	5·7	78·9	....	116·0	41·3	0·7	158·0	....
1917	56·3	25·0	9·7	91·0	....	95·0	55·0	....	150·0	....
1918	58·0	26·2	10·1	94·3	....	102·2	44·7	3·0	149·9	....
1919	56·7	24·6	9·7	91·7	....	78·1	26·9	....	107·3	....
1920	54·7	23·4	16·2	94·3	....	91·8	35·1	†6·8	129·1	....
1921	54·6	23·4	16·8	94·8	....	94·2	27·8	1·4	123·4	....
1922	62·2	24·9	24·1	111·1	....	110·8	33·5	....	145·1	....
1923	53·5	22·4	13·5	89·4	....	96·0	35·4	0·7	132·1	....
1924	55·0	23·7	15·7	94·4	....	88·8	36·8	1·4	127·0	....
	Bassano					Carmanguay				
1915	6·5	60·2	....	66·7	....	41·9	....	2·0	43·9	....
1916	....	....	....	....	....	32·6	....	....	32·6	....
1917	17·9	154·3	95·4	267·6	....	31·3	....	....	31·3	....
1918	....	....	....	211·0	....	29·8	......	1·0	30·8	....
1919	....	....	....	194·7	....	32·5	....	1·2	33·7	....
1920	....	....	....	158·9	....	26·2	....	*3·4	30·3	....
1921	....	....	....	137·8	....	....	....	....	....	....
1922	....	....	....	135·7	....	....	....	....	....	....
1923	....	....	....	150·8	....	No	Records	....	....	....
1924	....	....	....	176·8	....	....	....	....	....	....
	Medicine Hat					Redcliff				
1915	181·0	28·0	15·0	224·0	....	31·1	6·8	....	37·9	....
1916	214·0	....	....	214·0	....	36·8	22·1	1·0	59·9	....
1917	257·0	....	....	257·0	....	42·5	30·3	....	72·8	....
1918	....	....	....	264·0	....	66·4	22·4	....	88·8	....
1919	....	....	....	234·0	....	79·1	13·7	....	92·8	....
1920	....	....	....	206·8	....	67·9	16·2	....	84·2	....
1921	....	....	....	175·3	....	65·7	9·6	0·46	75·76	....
1922	....	....	....	187·9	....	97·9	7·8	....	105·6	....
1923	....	....	....	213·4	....	82·9	8·1	....	91·0**	....
1924	....	....	....	222·2	....	136·6	8·4	....	145·0	....
	Athabaska									
1915	....					14·3	....	....	14·3	....
1916	....					10·9	....	....	10·9	....
1917	....					24·0	....	....	24·0	....
1918	....					27·6	....	....	27·6	....
1919	....					26·1	....	....	26·1	....
1920	....					44·3	....	....	44·3	....
1921	....					33·3	....	....	33·3	....
1922	....					....	....	....	27·8	....
1923	....					....	....	....	19·8	....
1924	....					18·0	....	0·2	18·2	....

†4 months. * 7 months. **Based on 4 months Records.

Cities and Towns in the Province of Saskatchewan—Record of Average Daily Water Consumption in Imperial Gallons for Years 1915-16-17-18-19-20-21-22-23-24

Year	Per Head Domestic	Per Head Industrial	Per Head other Purposes	Per Head all Purposes	Unaccounted for	Per Head Domestic	Per Head Industrial	Per Head other Purposes	Per Head all Purposes	Unaccounted for
	Regina					Saskatoon				
1915	55·0	7·5	0·1	62·6	....	21·6	13·9	2·2	45·6	7·9
1916	66·1	7·8	....	68·9	....	21·0	15·4	1·9	52·6	14·3
1917	59·2	12·6	0·3	72·1	....	24·4	15·6	5·8	66·4	20·6
1918	56·9	11·1	0·1	68·1	....	27·1	17·2	2·4	63·1	16·4
1919	42·8	8·3	....	51·2	....	28·0	16·3	1·9	64·1	17·9
1920	48·9	9·1	*0·9	58·8	....	29·4	14·3	6·1	74·1	24·4
1921	49·6	10·12	2·1	62·56	0·74	29·5	20·3	1·05	72·05	21·2
1922	59·2	12·6	2·5	74·5	....	31·0	23·6	1·5	78·4	22·4
1923	61·7	14·5	2·0	78·2	....	28·8	20·8	1·5	71·0	23·1
1924	65·1	9·7	1·5	76·7	0·4	27·9	19·2	2·4	69·3	19·8
	Weyburn					Estevan				
1915	17·4	....	0·4	17·8	....	9·5	7·1	1·5	18·1	....
1916	16·9	....	0·3	17·2	....	8·2	5·7	1·0	14·9	....
1917	30·1	....	....	30·1	....	9·7	5·5	4·3	19·5	....
1918	26·4	....	....	26·4	....	9·3	0·7	7·2	17·2	....
1919	25·5	....	....	25·5	....	9·6	2·9	....	12·5	....
1920	30·2	....	....	30·2	....	9·3	4·4	....	13·7	....
1921	27·1	....	....	27·1	....	6·1	4·7	2·0	12·8	....
1922	....	....	....	64·4	....	8·5	6·4	2·9	17·9	....
1923	....	....	....	68·0	....	8·6	10·8	1·4	20·3	....
1924	....	....	....	77·4	....	9·2	6·1	2·9	18·2	....
	Moose Jaw					North Battleford				
1915	24·1	4·6	....	28·7	....	6·6	1·3	2·7	14·8	4·2
1916	35·2	12·3	....	47·5	....	9·5	2·0	4·9	22·7	6·3
1917	45·8	13·1	....	58·9	....	10·2	2·2	4·0	23·1	6·7
1918	31·6	15·4	....	47·0	....	10·0	4·8	3·0	26·3	8·5
1919	24·8	15·1	....	39·9	....	11·5	1·6	4·4	29·7	12·2
1920	24·5	14·5	....	39·1	....	11·3	5·8	5·9	34·0	10·9
1921	30·9	3·9	6·2	41·0	....	9·7	2·8	2·9	26·7	11·3
1922	34·8	9·0	....	43·8	....	11·0	2·8	4·3	34·1	15·9
1923	34·9	9·4	....	44·3	....	11·3	1·6	4·4	25·0	7·7
1924	36·5	8·0	....	44·5	....	10·8	2·3	3·7	33·4	16·6
	Kamsack					Kindersley				
1915	....	....	....	....	....	4·9	8·4	1·6	14·9	....
1916	....	....	....	....	....	5·5	26·8	....	32·3	....
1917	....	....	....	....	....	5·8	44·4	....	50·2	....
1918	31·6	66·3	....	97·9	....	6·0	8·9	....	14·9	....
1919	....	....	....	....	....	7·8	....	....	7·8	....
1920	....	....	....	....	....	6·9	17·5	....	21·5	....
1921	50·4	724·9	....	775·3	....	8·5	11·01	....	19·51	....
1922	50·3	690·2	....	740·6	....	10·1	12·3	....	22·4	....
1923	27·3	291·5	58·6	478·5	101·1	11·5	....	....	11·5	....
1924	24·8	194·4	6·3	394·2	168·7	....	....	....	11·0	....
	Prince Albert									
1921	....					....	....	....	83·0	....
1922	....					20·4	23·2	1·9	69·6	20·1
1923	....					22·8	27·1	1·6	70·0	18·5
1924	....					24·2	28·7	1·5	65·4	11·0

*10 months.

Surveys

Reservoir Reconnaissance

For the purpose of locating suitable sites where water could be economically stored in the foothills for irrigation and other purposes, a small party was placed in the field to examine the headwaters of all those streams between Calgary and the International boundary which had not been previously investi-

gated. The streams examined were the Castle and Carbondale rivers with such tributaries as Pincher, Canyon, Mill, Gladstone, and Link creeks; the Crowsnest river including Todd creek; the Oldman river including such tributaries as Callum, Racehorse and Dutch creeks, and the Livingstone river. The actual time spent on these investigations was 109 days.

While a number of small sites were located the result of the investigation was disappointing. The only storage site on Pincher creek is the one about 2 miles above the town of that name, which had been surveyed by the department in 1920. No suitable sites were located on Canyon, Mill, Gladstone, or Link creeks. On the Castle river no sites were located other than those already surveyed by the department known as the Castle and Canyon creek sites.

On the Carbondale river 1 mile above its junction with the Castle river a good dam site was located but, owing to the fact that the river falls very rapidly here, there is no basin of any considerable size in which to store water A dam at this point with a maximum height of 125 feet would have a crest length of 400 feet. Such a dam would back the water up for a distance of only $2\frac{1}{2}$ miles.

A possible site was located on the Crowsnest river in secs. 25, 26 and 27, tp. 7, rge. 2, W. 5th mer. A very careful reconnaissance was made of this site from which it has been determined that the cost per acre-foot of storage would be about $35. This is considered excessive. No other sites were located on this river with the exception of Crowsnest lake at the summit. The development of this site would flood out the Canadian Pacific Railway and the main highway, both of which closely parallel the lake shore.

On Todd creek a small site was located in sec. 30, tp. 9, rge. 2, W. 5th mer. About 500 acre-feet of water could be stored in a small lake adjoining this creek, by a diversion from the creek. This site would be of some value to private irrigation schemes along the creek.

The only site on the Oldman river is the "Gap" in the Livingstone ridge just below the mouth of Racehorse creek. This site has already been surveyed by the department. No sites were located on Callum, Racehorse or Dutch creeks, or on the Livingstone river.

Reservoir Detail

A party consisting of 9 men was employed to make surveys of a number of reservoir sites at the headwaters of the North Saskatchewan river. Complete surveys were made of what have been called the "Whirlpool Site" in tp. 35, rges. 18 and 19, and the "Gap" site in tp. 39, rges. 14 and 15, both on the North Saskatchewan river W. 5th mer. In addition to this, some work was done on what has been called the Cline River site in tp. 37, rges. 19 and 20, W. 5th mer. It was early determined, however, that this would not be an economical development and the work was abandoned.

Whirlpool Site.—A good dam site was found at the Whirlpool, offering natural spillway facilities at some distance to one side of the main river channel. It is estimated that by constructing a dam with a maximum height of 165 feet it is possible to impound 335,302 acre-feet of water at a cost of $1,999,372, or at the rate of $5.96 per acre-foot. The estimated cost is based on a rock fill dam with a crest length of 1,150 feet. The flood water is disposed of by means of a concrete spillway 1,550 feet in length with a maximum height of 37 feet. The flooded area is estimated to be 6,100 acres of which 2,150 acres is covered with marketable timber.

Gap Site.—Two dam sites were surveyed at "The Gap." The lower one was investigated for a dam with a maximum height of 155 feet and crest length of 1,650 feet. This would impound 219,680 acre-feet of water, the flooded area being 4,130 acres. The upper site was investigated for a dam with a maximum height of 147 feet and crest length of 2,800 feet and would impound

283,360 acre-feet of water, the flooded area being 4,177 acres. No natural spillway facilities exist at either of the sites so that all flood water would have to be passed over the dam.

In order to provide for the flood waters of the North Saskatchewan river which at this point is estimated to be about 92,000 sec.-ft. it would be necessary to construct an overflow weir for the full width of the stream at either of the sites. Such a structure would be extremely costly and for the amount of water impounded could not be considered economical.

Operating Irrigation Projects

THE CANADIAN PACIFIC RAILWAY COMPANY

Western Section.—This project diverts its water from the Bow river on Sec. 13, tp. 24, rge. 1, W. 5th mer. just east of the city of Calgary, for the irrigation of 218,980 acres, practically all of which are occupied.

The 1924 operating season was the seventeenth for this section and although progress from an irrigation standpoint has been slow, improvements in farming methods have been noted and the project as a whole is making steady progress. Early rains gave the crops an excellent start, but the delayed July rains and the hot winds in the early part of that month did much damage. In spite of past experience with similar conditions, the farmers failed to prepare for irrigation until it became too late to apply water beneficially to all their irrigable area under crop and, as a result, yields were greatly reduced throughout the district. During the 1924 season 24,297 acres were irrigated, an increase over the 1923 area of 21,223 acres. To this area 342,715 acre-inches of water were delivered, representing an average depth per irrigable acre of 14.1 inches. The number of actual water users during the season amounted to 881, which is a considerable increase over previous years. The principal irrigated crop was wheat, which represented approximately 70.7 per cent of the total irrigable area. Other crops grown included oats, 5,040 acres; barley, 1,436 acres; hay, 2,098 acres. The following table shows the areas in crop on water-right lands, the yields obtained and the market price at time of harvest:—

Crop	Area in acres	Total yield	Yield per acre	Unit value	Total value
					$
Wheat	155,000	2,170,000 B	14B	1·25	2,712,500
Oats	35,000	1,050,000 B	30 B	0·40	420,000
Barley	5,000	100,000 B	20 B	0·55	55,000
Rye	1,000	15,000 B	15 B	1·00	15,000
Flax	500	2,500 B	5 B	1·80	45,000
Hay	5,000	5,000 T	1 T	10·00	50,000
Green feed	10,000	12,000 T	1·2 T	6·00	72,000
Sunflowers	400	2,000 T	5 T	3·00	6,000
Corn	400	800 T	2 T	3·00	2,400
Potatoes	300	22,500 B	75 B	1·00	22·500
	212,600				3,400,400

B = bushels. T = tons.

The very considerable advance in price of all grains at the close of the 1924 season, compensated to a great extent for the reduced yields, resulting from delayed irrigation. The average value of the yields from the water-right lands amounted to $16.09 per acre, and from the non-irrigated lands practically the same. In 1923 the figures were $17.09 per acre from the irrigated and $11.83 from the non-irrigated lands.

The average precipitation at Strathmore during the growing season compared with the 1923 season is given hereunder:—

Month	Precipitation in inches		Mean average for 12 years at Strathmore	Mean temperatures		Remarks
	1923	1924		1923	1924	
April	0·85	0·81	0·99	38·50	37·05	Precipitation for 1923-24 are averages of 8 stations scattered throughout the district.
May	4·27	0·67	1·99	49·60	51·38	
June	5·13	4·17	2·72	54·00	54·13	
July	2·62	1·49	2·09	62·30	63·30	
Aug	1·95	2·31	2·19	59·45	58·00	
	14·82	9·45				

The period free from damaging frosts covered 112 days. Water was turned into the system from the Bow river on April 30, and closed down on October 18, 1924.

Eastern Section.—This project which also diverts its water from the Bow river at the Horseshoe Bend dam on the Blackfoot Indian reserve in tp. 21, rge. 19, W. 4th mer. has now been in operation for 11 years. It has a total irrigable area of approximately 400,000 acres, of which approximately 120,000 acres have already been disposed of for settlement. The area actually irrigated during the past season was 84,200 acres as compared with 42,928 acres in 1923—an increase of 41,272 acres. Some 171,481 acre-feet of water were delivered for the irrigation of this area, representing an average depth of 2.03 feet per acre. The number of actual water users was 733, a decrease of 76 compared with 1923. The principal irrigated crop in this section was wheat which represented approximately 47 per cent of the total crop area. The following table gives the cropped area and yields received and the unit prices for the past year:—

Crop	Area in acres	Total yield	Yield per acre	Unit value at harvest	Total value
				$ cts.	$
Wheat	41,664	549,176 B	13·2 B	1 35	741,387
Oats	12,939	295,015 B	22·8 B	0 43	126,856
Barley	6,499	127,048 B	19·6 B	0 59	74,958
Flax	2,183	18,501 B	8·5 B	2 00	37,002
Peas	125	625 B	0·5 B	3 60	2,250
Alfalfa seed	4,010	5,380 B	1·35 B	18 00	96,840
Rye	118	275 B	2·33 B	1 01	278
Alfalfa	10,071	20,446 T	2·04 T	8 00	163,568
Hay	7,916	6,905 T	0·87 T	8 00	55,240
Sunflowers	40	106 T	2·65 T	7 00	742
Corn	393	681 T	1·70 T	8 00	5,448
Potatoes	79	272 T	3·45 T	30 00	8,160
New alfalfa	2,157	352 T	0·16 T	8 00	2,816
Garden roots, etc	418	417 T	1·00 T	19 20	8,006

B = Bushel. T = Ton.

As mentioned in last year's report on this project, a number of farmers in this section have gone into the alfalfa seed industry and have established an up-to-date seed cleaning plant at Brooks. The registered seed from this plant has had a very ready sale at prices which have been profitable to the growers.

The company has again expended considerable sums on repairs and betterments during the past season. One of the largest items of expenditure has been in connection with drainage ditches for surplus surface irrigation water and spillway channels.

There were 123 days free from frost at Brooks during the year, from May 9 to September 24. The total precipitation at Brooks for the twelve months was 9.96 inches, of which 7.57 inches was received during the growing season, made up as follows: April, 0.28; May, 0.99; June, 1.53; July, 1.20; August, 2.59; September, 0.98.

The company has undertaken a number of valuable experiments in various parts of the section with a view to relieving alkali and seepage conditions. In this connection approximately 50 quarter-sections have been under review during the season. An interesting experiment is being carried out on the company's reservations at Brooks and Cassils. Areas of valuable land in this vicinity have been damaged by the rise of alkali and an attempt is being made to reclaim these lands by two different systems. These operations consist of under-drainage and flooding. Level checks and sloping checks have been prepared and water is kept constantly ponded on the level checks so that the alkali in the soil may be dissolved and then carried down through the drains. The idea with sloping checks is to be able to quickly flush off the surface with large heads of water and carry off some of the surface salts to the adjacent surface drains.

Lethbridge Section.—This project diverts its water from the St. Mary river in sec. 36, tp. 1, rge. 25, W. 4th mer. The area under water agreements at the close of 1924 was 74,658 acres of which 71,700, or 96 per cent were irrigated. The area which is at present receiving water is 83,500 acres and includes leased and rented lands for which no water agreements have been filed. The average per acre value of the crops raised on the irrigated lands during the season was $26.53, as compared with $18.81 in 1923. These figures have been obtained from the area actually cropped and exclude 20,758 acres of irrigated pasture lands, leaving a net area of 50,942 acres of water-right lands under crops. The average per acre value of the crops raised on the non-irrigated lands in the district was $20.78, as compared with $16.30 in 1923. The total value of the crops grown on the water-right lands is estimated at $1,351,545 and at $345,580 on the non-irrigated lands. There were 940 actual water users during the season. Water was turned into the system on April 26, and the system operated continuously until October 22.

The average per acre yield of wheat in 1924 was 20.13 bushels, as compared with 28.9 bushels in 1923. In spite of the low yields from the irrigated lands due to late and insufficient applications of water, they produced nearly 9 bushels per acre more than the dry lands. This increase is equivalent to approximately $12 per acre in favour of irrigated lands. A summary of the areas in crop, the yields obtained and the market price at time of harvest is given hereunder:—

Crop	Area in acres	Total yields	Average yield per acre	Unit value at harvest	Total value	Value per acre
				$ cts.	$ cts.	$ cts.
Wheat	17,365·51	349,526 B	20·13	1 35	471,860 10	27 17
Oats	4,379·86	165,505 B	37·80	0 50	82,752 50	18 89
Barley	2,719·00	74,312 B	27·33	0 75	55,734 00	20 50
Flax	872·00	11,278 B	12·93	2 00	22,556 00	25 87
Alfalfa	12,543·76	27,256 T	2·17	10 00	272,560 00	21 73
New alfalfa	444·00	257 T	0·58	10 00	2,570 00	5 79
Rye	18·00	675 B	37·50	1 10	742 50	41 25
Timothy	6,610·05	7,454 T	1·13	13 00	96,902 00	14 66
Alfalfa and timothy	661·00	1,239 T	1·87	10 50	13,009 50	19 63
Green feed	1,785·40	2,599 T	1·46	10 00	25,990 00	14 55
Hay	1,617·30	1,953 T	1·21	11 00	21,483 00	13 28
Sunflowers	79·00	758 T	9·59	5 00	3,790 00	47 97
Corn	284·75	2,271 T	7·98	6 00	13,626 00	47 85
Peas	26·00	830 B	31·92	3 00	2,490 00	95 77
Potatoes	978·80	3,605·43 T	3·68	26 00	93,741 18	95 77
Sugar beets and other roots	88·75	917 T	10·30	8 00	7,336 00	82 66
Garden truck	469·00	2,740 T	5·84	60 00	164,400 00	350 53
Totals	50,942·18	....	....	....	1,351,542 78	26 53

B = bushels. T = tons.

With the moisture carried over from the previous fall and with the light May rains, the crops generally made an excellent start; in fact throughout most of June there were no indications that they were suffering. Towards the end of June, however, the general conditions changed rapidly. With no reserve of moisture in the soil it only required the few hot days of early July to cause damage which subsequent irrigations could not repair. The rainfall in inches at Lethbridge during the growing season was as follows: April, 0.56; May, 1.17; June, 3.82; July, 0.54; August, 2.91; September, 1.46; equal to 10.46 inches, the total for the year being 16.0 inches. The period free from damaging frosts extended from May 13 to September 26, equal to 136 days. There was no serious damage caused either from hail or pests during the season.

There has been an appreciable increase in live-stock during the past year, and this is particularly noticed in the numbers of dairy cows and sheep recorded. Beekeeping has also made promising headway, the 1923 returns showed 263 colonies whereas the 1924 returns show 781 with a honey crop valued at $10,475.

In addition to the usual maintenance and repair work the company undertook the reconstruction of their main diversion headworks. The new works consist of 6 radial sluice-gates and 4 headgates—each 14 feet wide, set in a new pile and timber structure 110 feet down stream from the east end of the existing dam. These works will eliminate the oldest section of the weir and the existing headgates, intake and wastegates. Work on the new structure was commenced in August and continued until December 15, when severe weather conditions necessitated closing down. There still remains about 6 weeks work to complete the scheme of improvements as at present outlined. The cost of the improvements at this point has been estimated at $85,000.

Improvements were made during the season on the outlet channel of Molloy lake, which forms a collecting basin for the surplus waters of the Coaldale and east laterals and the spillway of the Cameral lateral. About 4½ miles of drainage canal were excavated. On the main canal earthwork construction has been undertaken at points where banks required raising and strengthening. In addition to the regular repair work on structures necessary for efficient operation a number of structures have been renewed; these include service wastegates, drops, bridges and culverts on laterals and steel gates on main canal.

On lateral canals and spillway channels some 10 miles were cleared of silt at a cost of approximately 12.6 cents per cubic yard.

The increase in the number of dairy cattle throughout the district has resulted in a movement to build a cheese factory at Coaldale.

TABER IRRIGATION DISTRICT

This district obtains its water supply from the St. Mary river through the works of Canadian Pacific Railway Company's Lethbridge section, formerly the Alberta Railway and Irrigation Company. The 1924 operating season was the fourth since construction. The district contains a total irrigable area of 17,249 acres and is operated and managed by a secretary-manager who is assisted during the season by two ditch riders. Other labour in connection with the maintenance of the system is engaged from time to time as required.

This district has made steady progress since its formation and has met all its obligations. The operation and maintenance charge during the past season was $1.50 per irrigable acre, which also covers the annual charge for redemption of the bonds.

During the 1924 season 13,051 acres were actually irrigated—which represents 75.7 per cent of the irrigable area and is an increase over the 1923 area of 9,426 acres. The number of farm units receiving water was 122, with an average area of 196 acres. A total of 33,159 acre-feet of water was delivered

into the system and of this amount 12,475 acre-feet were used during September, October, and November for fall irrigation. The highest monthly use being 7,535 acre-feet, delivered in October. Water was turned into the system on May 9, and closed down on November 4, owing to ice conditions.

The crop returns for the year are not as satisfactory as might have been expected from the amount of water diverted into the system. This was partly due to the fact that most of the farmers are attempting to develop holdings much in excess of the area considered economic under irrigation conditions. Most of the land needs some levelling before the water can be properly applied and much greater attention should be given to the proper location and spacing of the farm ditches and laterals. Weather conditions over a great part of the area were also unfavourable. A summary of the area cropped, the yields received and unit prices at harvest is given hereunder:—

Crop	Area in acres	Total yields	Average yield per acre	Unit value at harvest	Total value	Value per acre
				$ cts.	$	$ cts.
Wheat	9,173	121,400 B	13·2 B	1 35	163,890 00	17 86
Oats	1,542	46,427 B	30·1 B	0 50	23,213 50	15 05
Barley	1,048	21,912 B	20·9 B	0·75	16,434 00	15 67
Flax	75	150 B	2·0 B	2 00	300 00	4 00
Alfalfa	1,359	3,106 T	2·3 T	10 00	31,060 00	22 00
New alfalfa	225	....	....	....	....	....
Rye	39	496 B	12·70 B	1 10	545 60	14 08
Timothy	189	204 T	1·08 T	13 00	2,652 00	14 04
Green feed	687	982 T	1·40 T	10 00	9,820 00	14 30
Hay	176	200 T	1·10 T	11 00	2,200 00	12 50
Potatoes	36	166·56	4·60 T	26 00	4,330 56	120 12
Totals	14,549	....	....	....	254,445 66	17 48

B = bushels. T = tons.

The acreage in corn has increased from 12 acres in 1923 to 126 acres. This crop was generally used for hog pastures and no information as to the per acre yields is available. Experiments were conducted by a number of farmers in growing sugar beets. Alfalfa growing has made very satisfactory progress, the total acreage now being 1,584 acres, as compared with 900 acres in 1922. Considerable interest has also been taken in the growing of alfalfa seed, some 10,000 pounds being threshed during the past season, as compared with 400 pounds in 1923.

The hog-raising industry has made commendable progress during the past year. The number reported in the district at the end of 1924 was 3,396 as compared with 989 in 1923, and 133 in 1921.

The farmers in this district appear to be fully alive to the value of organization and of the benefits of community service. A Farmers' Institute and a Farm Development Board have been formed to solve the many problems incident to irrigation farming. Regular meetings are called and speakers obtained from outside the district from time to time to give advice and direct the efforts of these respective organizations.

At the request of the district officials an investigation was made during the month of October for the purpose of reclassifying certain parcels of land in the present district and extending the district to include some more suitable lands immediately to the south of the town of Taber. It was found quite feasible to make such an extension and the question is now under consideration by the department.

CANADA LAND AND IRRIGATION COMPANY

This project diverts its water from the Bow river in sec. 31, tp. 21, rge. 25, W. 4th mer. There are some 530,250 acres of land originally acquired by the company of which approximately 202,640 acres are irrigable.

In April, 1924, the water users were officially notified by Mr. E. J. Bennett, of Toronto, who had previously been appointed receiver of the Canada Land and Irrigation Company, that the company would be unable to deliver water during the 1924 irrigation season. The appointment of a receiver was the result of action taken in England by the holders of the prior lien debenture stock issued by the company. The seriousness of the situation created in so far as the water contract holders were concerned was realized by the department and arrangements were soon under way to give whatever advice and assistance was necessary to the farmers affected. The contract holders of the Canada Land and Irrigation Company and the water users of the New West district being equally affected by the cessation of operations, formed what is now known as the Amalgamated Water Users' Association and drew up the necessary Articles of Association and Memorandum of Agreement. Owing to the serious condition of some of the major structures and a portion of the main canal and in view of the necessity of supplying these settlers with water, if they were to remain on the land, it was decided to extend a credit of $20,000 to a duly accredited representative of the settlers within the tract, such credit to be guaranteed by the Government on the understanding that all sums advanced be expended on necessary repairs to the existing works. It was also arranged that all vouchers in connection with such expenditures be approved by an officer named by the Minister of the Interior. The funds which were thus made available were expended mostly on the construction of a large metal flume on the Little Bow section of the main canal at a point where serious trouble was being experienced from sliding banks.

The operation of the project from lake McGregor reservoir to the irrigated lands was undertaken by the Amalgamated Water Users' Association and very satisfactory service was given as soon as the necessary repairs had been undertaken. The charges made for the operation and maintenance service which was thus improvised was on a basis of $1.25 per irrigable acre to the water contract holders of the Canada Land and Irrigation Company and $1.04 to the water users under the New West irrigation district. The difference in the rates charged being due to the New West district taking delivery of water at the district's headgates and distributing it independently of the Water Users' Association, whereas the higher rate charged the settlers of the Vauxhall unit included distributing service.

In spite of irrigating under adverse conditions, as regards facilities for operating the canal system, together with a season of restricted rainfall, the farmers under this project harvested crops which compare favourably with those of other projects. Owing to unavoidable delays in the repairs to the canal section between lake McGregor and the Little Bow reservoir, an acute shortage of water was experienced in July which seriously set back the growing crops and materially reduced the yields. The records of rainfall in inches at Vauxhall from May to September were: May, 0.34; June, 1.10; July, 0.46; August, 2.86; September, 0.71; a total for the period of 5.47 inches, as compared with 12.31 inches for the same period in 1923. The frost-free period extended from May 30, to September 25, or 118 days. With the exception of the first 2 weeks in July when high temperatures with strong southwest winds rapidly exhausted the available supply of moisture, the season generally was favourable for growth providing irrigation was intelligently practised. Very favourable weather conditions prevailed during haying, with the result that alfalfa and fodder crops were put up in good condition for marketing. On the irrigated

lands there were 10,094 acres cropped of which 9,730 acres were irrigated, as compared with 10,373 acres cropped with 6,815 acres irrigated in 1923. The total estimated value of the crops grown on the 10,094 acres was $242,549.30, which represents an average per acre value of $24.03, as compared with $20.41 in 1923. The per acre yields were lower than those of 1923, but in view of existing conditions the district has made satisfactory progress. The general higher market values obtaining in 1924 more than offset the returns received from the larger yields of the previous year. A summary of the cropped area, yields, and values for the past season is shown in the following table:—

Crop	Area in acres	Total yields	Average yield per acre	Unit value at harvest	Total value	Value per acre
				$ cts.	$	$ cts.
Wheat	4,763·32	84,012 B	17·64	1 35	113,416 20	23 81
Oats	1,279·76	47,997 B	37·50	0 50	23,998 50	18 75
Barley	1,280·59	30,198 B	23·60	0 75	22,648 50	17 69
Potatoes	79·00	13,121 B	166·00	0 90	11,808 90	149 47
Alfalfa	1,914·33	5,452 T	2·85	10 00	54,520 00	28 48
Timothy	24·00	36 T	1·50	13 00	468 00	19 50
Green feed	175·34	208 T	1·19	10 00	2,080 00	11 90
Corn, sweet	2·00				100 00	50 00
Corn, silage	62·00	704 T	11·40	6 00	4,224 00	68 13
Sugar beets	3·50	35 T	10·00	8 00		
Alfalfa seed	102·00	8,000 lbs	78·43	0 40		
Beans	2 00					
Pasture	366·76			20 00	7,335 20	20 00
Truck gardens	39·00			50 00	1,950 00	50 00
Totals	10,093·60				242,549 30	24 03

B = bushels. T = tons.

It is interesting to note in connection with the live stock industry in this district that some 8,500 head of sheep and 750 head of cattle were brought into the district during the fall for winter feeding. This will simplify the marketing of a large portion of the district's surplus fodder crop.

LETHBRIDGE NORTERN IRRIGATION DISTRICT

This district diverts its water from the Oldman river on the Peigan Indian reserve in tp. 8, rge. 27, W. 4th mer. The district covers an area of 220,000 acres, of which 105,012 are irrigable. As outlined in last year's report, the damage wrought by the June, 1923, flood was not repaired until September 30, so that water was not available for the 1923 crop; 6,963 acres were, however, fall irrigated, which was beneficial to the 1924 crop. During the past season water was turned into the system on April 10, and ran continuously until October 23. Of the water diverted 12,000 acre-feet were stored in Keho Lake reservoir and will be available for a large territory in the eastern end of the district should it be required for early spring irrigation. At the beginning of the irrigation season many of the farmers were unprepared to irrigate and at the request of the district officials some assistance was rendered by the department. Between May 26, and June 25, 7 engineers were assigned to the work of surveying farm laterals. Although these engineers spent from 6 to 14 days in the district and during this period staked out farm laterals for 103 quarter-sections and advised the farmers as to the proper methods of irrigating their lands, very few were prepared to make the most efficient use of the water. The area actually irrigated during the season was 45,016 acres according to the annual return submitted by this district, and of this area, 29,991 acres were irrigated during the growing season. During the fall months many farm laterals were constructed throughout the tract and water applied to 15,025 acres.

The soil types which prevail in this district will usually retain moisture so applied for the benefit of the next season's crop and thereby enable the farmer to proceed with his seeding and the preparation of his land and lateral systems. In this manner his first irrigation can often be safely delayed until well into June.

The principal crop grown in this district during the past season was wheat, of which 15,841 acres were seeded. The crop grown, with the yields obtained and their per acre value, are given hereunder:—

Crop	Area in acres	Total yields	Average yield per acre	Unit value at harvest	Total value	Value per acre
				$ cts.	$ cts.	$ cts.
Wheat	15,841	210,537 B	13·3	1 35	284,224 95	17 95
Oats	2,246	52,339 B	23·0	0 50	26,169 50	11 65
Barley	513	8,891 B	17·2	0 75	6,668 25	12 90
Flax	244	1,638 B	6·7	2 00	3,276 00	13 40
Rye	53	25 B	0·5	1 10	27 50	0 52
Alfalfa	414	690 T	1·7	10 00	6,900 00	16 67
Timothy	20	Nurse crop				
Hay	302	244 T	0·8	11 00	2,684 00	8 89
Green feed	1,924	1,668 T	0·9	10 00	16,680 00	8 67
Corn	33	43 T	1·3	6 00	258 00	7 82
Sugar beets	2	15·25 T	8·0	8 00	122 00	61 00
Potatoes	51	295 T	5·8	26 00	7,670 00	150 40
Sunflowers	1	....	....	....	....	....
New alfalfa	268	....	....	....	....	....
Totals	21,912	....	....	....	354,680 20	16 19

B = bushels. T = tons.

The district's operating organization consists of a project manager, a secretary-treasurer, 1 accountant, 1 hydrometric engineer, 4 watermasters and 20 ditch riders, other labour is hired from time to time as required. The district rate for the operation and maintenance service for 1924 was $1.48 per irrigable acre. Other charges levied to meet the bonded indebtedness amounted to $3.77, making a total per acre charge of $5.25.

UNITED IRRIGATION DISTRICT

This is virtually the first year of operation for this project. The works were completed in August, 1923, and a little water was used for fall irrigation, which should be considered as part of the moisture requirement for the 1924 crop. The district diverts its water from the Belly river in sec. 13, tp. 3, rge. 28, W. 4th mer. and contains some 36,150 irrigable acres; 5,264 acres, or only 14 per cent of the total, were actually irrigated during 1924, which represents the area upon which land preparation has been undertaken and farm laterals constructed. The individual holdings in this district are far too large and steps have already been taken to dispose of much of the surplus by renting and in a few cases by sale on a crop payment basis.

Water was turned into the system on May 1, and with the exception of a temporary shutdown from June 9 to 16, the system was in operation until November 3. During that period a total of 18,777 acre-feet was diverted from the river. The precipitation during the growing season as recorded at Hillspring was 16.33 inches, made up as follows: April, 1.05; May, 4.66; June, 6.34; July, 1.50; August, 1.90; September, 0.88. The generous rainfall received during May and June undoubtedly retarded activities towards preparation for receiving water for a July irrigation, which would have been beneficial as the first 3 weeks of that month were very hot and dry with damaging southwest winds. The major crop was wheat which gave a per acre return of

$41.69 on irrigated land. A summary of the crops grown on the lands actually irrigated, together with their average yield and value, is given hereunder:—

Crop	Area in acres	Total yield	Average yield per acre	Unit value at harvest	Total value	Value per acre
				$ cts.	$ cts.	$ cts.
Wheat	1,193	36,840 B	30·9	1 35	49,734 00	41 69
Oats	341	17,187 B	50·4	0 50	8,593 50	25 20
Barley	45	1,210 B	27·0	0 75	907 50	20 17
Corn	84	35 T	0·4	6 00	210 00	2 50
Alfalfa	283	526 T	1·9	10 00	5,260 00	18 59
New alfalfa	149	....	....	....	....	....
Timothy	373	488 T	1·3	13 00	6,344 00	17 01
Green feed	185	313 T	1·7	10 00	3,130 00	16 92
Other hay	139	199 T	1·4	11 00	2,189 00	15 75
	2,792	....	....	....	76,368 00	27 35

B = Bushels. T = Tons.

A certain amount of maintenance work was undertaken during the year and consisted chiefly in the removal of silt bars caused by weed deposits or soil drifting and weed burning. Under repairs and betterments a small expenditure was incurred. The district generally is in a very satisfactory condition both in regard to its financial obligations and the condition of its works. The operation and management of the district are undertaken by a secretary-manager who reports to and is directed by a board of trustees.

In 1923 the district employed an engineer to classify each separate parcel of land in accordance with the works as constructed. Plans of the district showing this classification were filed in this office early in the year but before accepting them as final it was decided to check the work in the field. This work consisted of a reclassification of 44,000 acres, the commanded area of the district, and was carried out by the department during the year. In order to complete this work a number of engineers, each with an assistant, were employed from time to time as they became available from their regular duties and altogether a total of 300 engineer-days were required to complete the field work. While the office work in connection with this reclassification is now well in hand the results are not yet available.

NEW WEST IRRIGATION DISTRICT

Although the works in connection with this district were completed in 1923, the past season can be considered as the first from an operation point of view. The water supply is obtained from the Bow river through the works of the Canada Land and Irrigation Company.

The district contains 4,501 irrigable acres, of which some 1,657 or 37 per cent were irrigated during the season. As there are only 17 water users at present in this district, it may be considered that a satisfactory showing has been made. Peculiarly adverse conditions were encountered during the year. Early spring found the soil exceptionally dry and no preparation made for applying the water. At the request of the district officials 2 engineers of the department were assigned to the work of locating and staking out farm laterals during the latter part of May and while this work was completed for 27 quarter-sections and the farmers advised as to the best methods of constructing their works and applying the water, the settlers were unable to carry out any useful irrigation of their lands. In consequence crops were sown in an unfavourable seed bed and in many cases did not germinate. The results were unfavourable. Efforts were made to apply water to some of the crops but with very little effect. The yields produced on the irrigated lands were, in consequence, very light, averaging generally 5 to 10 bushels per acre for wheat and barley and from 15 to 30 bushels for oats.

This district co-operated with the water users of the Canada Land and Irrigation Company in connection with the organization of the Amalgamated Water Users' Association, which was created as outlined in the report on Canada Land and Irrigation Company, for the purpose of operating the works of the company.

Water was turned into the system on May 11, and the headgates closed down on October 30. A total of 5,361 acre-feet of water was passed through the system during the season, of which it is estimated a large percentage was not used. It is interesting to note that the diversion during October greatly exceeded that of any previous month.

LITTLE BOW IRRIGATION DISTRICT

The diversion headworks and main canal for diverting the waters of the Highwood river into the Little Bow river were completed in the spring of 1924. Water has been diverted continuously throughout the year, the head being materially decreased during the winter months.

No attempt has been made to construct any of the individual schemes for the diversion of this water from the channel of the Little Bow river. Undoubtedly, the fact that the channel of the Little Bow river has been furnished with a continuous supply of fresh water has been very beneficial to the settlers along its course for domestic and stockwatering purposes. The license standing in the name of the Government of the province of Alberta for 50 cubic-feet of water per second from the Highwood river is now being diverted through these works by an arrangement between the district and the provincial authorities.

Organized Irrigation Districts

MOUNTAIN VIEW

This district is situated in tps. 2 and 3, rges. 27 and 28, W. 4th mer. and diverts its water from the Belly river on the SW. $\frac{1}{4}$ sec. 33, tp. 1, rge. 28, W. 4th mer. During the year 1922, plane-table surveys were made of approximately 3,500 acres of the most desirable lands and a general survey made of an additional area of some 2,500 acres of the more rolling lands. After erection the district officials requested that plane-table surveys be completed of the whole area. Consequently, an engineer was assigned to this work by the department during the year and the necessary surveys completed. An area of some 2,700 acres was plane-tabled, including the 2,500 acres over which preliminary surveys had previously been made. From these surveys the total irrigable area in the district has been estimated to be 4,200 acres and the cost $25 per irrigable acre. The order for the formation of the distict was published in the *Alberta Gazette* of August 15, 1923. Plans have now been submitted and authorization for the construction of the works will be issued in due course. It is not proposed to issue any bonds in connection with the cost of construction, as the farmers to be benefited are arranging to undertake the work co-operatively.

SOUTHERN

As outlined in last year's report under this heading, petitions had been submitted for a withdrawal of a portion of the lands which were included in the Southern Irrigation district. This withdrawal was duly consented to and the areas withdrawn now compose the lands which are included in the Magrath and Raymond districts.

MAGRATH

The necessary ministerial order for the erection of the district was promulgated on June 2, 1924, and appeared in the *Alberta Gazette* on June 14, 1924. The required water supply for the district is to be obtained by purchase from the Canadian Pacific Railway Company.

In January, 1925, the trustees reported considerable opposition to the further progress of the district as at that time constituted, and that many of the original petitioners wished to withdraw their lands. At a meeting held at Magrath on January 2, 1925, all those holding lands north and east of Dry coulee, comprising an area of some 3,832 irrigable acres, expressed an almost unanimous desire to withdraw from the district. The remaining petitioners were in favour of proceeding with the development of the balance of the district, provided they were allowed to restrict their irrigable area to 40 acres per quarter-section or any unit of less than a quarter-section, where such amount was irrigable. A request was then received for an amended estimate of cost and this was duly prepared and submitted to the trustees on February 17, 1925. The area has been reduced to 5,213 irrigable acres under this rearrangement. No further developments can be reported until these amended estimates have been presented to a general meeting.

RAYMOND

Some progress has been made during the past year in connection with the formation of this district. Notice of application under the provisions of the Irrigation Districts Act of Alberta was published in the *Alberta Gazette,* dated November 29, 1924. The lands affected are situated in tp. 6, rges. 19, 20, and 21, and lie due west of the town of Sterling. It is proposed, subject to arrangements, to take over the Raymond-Sterling lateral of the Canadian Pacific Railway Company's Lethbridge Section project and operate it, that existing water users be taken care of by the new district organization.

MEDICINE HAT EASTERN

The situation in regard to this district was fully outlined in the 1923-24 report. Since then the Government of the province of Alberta decided not to grant financial assistance to the district by way of debenture guarantee, but, in spite of this, the district requested that their application for a reservation of water from Ross and Bullshead creeks be not cancelled as they desired to have further time in which to arrange for financial assistance. In consequence of this request a further extension was granted.

ROBSART-VIDORA

The necessary ministerial order for the erection of the district duly appeared in the *Saskatchewan Gazette* on December 31, 1923. No further action was taken by the district until December, 1924, when they called in a consulting enginner, to assist them in connection with their plans and estimates for submission to the local government board in compliance with the Saskatchewan Irrigation Districts Act. This action on the part of the district would indicate that they intend to advance the project another step towards the construction of the necessary works.

SOUTH MACLEOD

The development of this district may be considered as held in abeyance pending the disposal of the surplus lands of those irrigation districts to which the Government of the province has pledged its credit. In August, 1924, the provincial authorities appointed Mr. H. A. Bright, of Macleod, an official trustee for the district, with the necessary power to levy a rate on the original petitions sufficient to clear up the outstanding indebtedness.

Proposed Irrigation Districts

Lethbridge Southeastern Project.—Of the various areas investigated under this project the Southern, Magrath and Raymond have been formed into districts under the Irrigation Districts Act of Alberta, but very little further progress can be recorded at this time.

Milk River—Warner District.—A petition for the erection of this district was submitted to the Minister of Railways and Telephones of the province on February 20, 1920, but no further progress whatever has been made by those interested since that date.

New Dayton District.—A petition for the erection of this district, which is situated immediately to the east of the Southern district, was submitted to the Minister of Railways and Telephones of the province on October 10, 1921, but no further progress has been made since that date.

Retlaw-Lomond Irrigation Project.—As reported last year, plans and estimates of cost have been prepared for two alternative schemes to supply this project with water, viz.,—

(*a*) By an extension of the canal system of the Lethbridge Northern irrigation district, and

(*b*) By an extension of the canal system of the Canada Land and Irrigation Company.

No action has been taken by the few remaining settlers in this territory towards the erection of a district as extensive as that covered by either of the schemes presented. Meetings have, however, been held and delegations have visited the Calgary office for further information and advice, but no definite action has been taken by any of the parties concerned.

Champion Irrigation Project.—During the past year a further study has been made in connection with an alternative scheme of diversion from the Highwood river to Frank Lake reservoir, where the required water for the project would be stored. As a result of these further investigations an amended scheme with diversion headworks at the site of the existing headworks of the Little Bow irrigation district, has been designed and cost estimates and plans prepared. With headworks so located the diversion canal would follow the location of the existing canal of the Little Bow Irrigation district for a distance of about 4,500 feet and then branch off in a northerly direction, joining the original canal location in the SE. $\frac{1}{4}$ sec. 17, tp. 19, rge. 28, W. 4th mer. From this point of intersection with the original canal line, the revised location practically follows the original one to Frank Lake reservoir. This revision eliminates the Tongueflag reservoir and increases the capacity of the diversion canal some 600 cubic feet per second in order that the quantity of water required for the project may be diverted to storage during the periods that it is available; also the capacity of Frank lake is increased from 55,370 acre-feet to 72,000 acre-feet, which is more than the combined storage of the 3 reservoirs originally contemplated. The final revised estimates of cost show a saving for the project of some $429,067, which, on the basis of 52,435 irrigable acres, represents a per acre saving of $8.18.

No further steps have been taken during the past year by those interested in the development of this project towards the erection of an irrigation district.

Experimental and Test Plots

ALKALI TEST PLOTS AT MAPLE CREEK, SASKATCHEWAN

The object of this work was fully explained in the 1922-23 annual report. Work was contined on these plots during the past year. The plots were seeded to alfalfa, sweet clover and grasses and received three irrigations to depths of 6 inches, 4 inches and 4 inches, respectively. No alkali has appeared on the surface of the plots proper, although some hoar frost alkali has developed in the vicinity on a plot irrigated but not included in the experimental area. The types of fodder crops seeded have all done well and the results of the experiment are thus far very favourable and encouraging, considering the amount of alkali

present in the soil. It is indicated to date that heavy soils of this nature are primarily adapted for deep rooted plants which are less easily affected by surface drying and baking, but it is still too early to attempt to draw any permanent conclusions regarding the productivity of such soil types under irrigation.

EAST CYPRESS HILLS DISTRICT—EXPERIMENTAL PLOTS

It was planned to have 3 experimental plots in operation in 1924 in the East Cypress Hills district. These plots were chosen and surveyed by the engineer in charge of that district after the owners had signified their willingness to co-operate in carrying out the work under the direction of the inspecting engineer. Unfortunately for various reasons two of the three owners found it impossible to put their plots in shape for operation last year. The other, situated close to Consul, Sask., prepared a 10-acre plot, which had been summer-fallowed the previous year, by carefully floating the land. He then laid out the plot under ditches and borders and seeded it to alfalfa. An excellent stand was obtained but no irrigation was carried out, partly on account of the abundant rainfall experienced, and partly because the main irrigation system required repairs which were not carried out owing to the pressure of other work. This plot should be in the best of condition for irrigation demonstration this coming year.

Farm Demonstration, 1924

Outline of Work.—The program of irrigation demonstration work as adopted for the 1924 season provided for the maintenance of 12 plots of approximately 5 acres each, upon which the irrigation specialist would apply, by economical methods, the exact amount of water required supplementary to the rainfall to provide the crop grown with an adequate amount of water, and in other ways demonstrate the principles of irrigation practice to the farmer and his neighbours.

Two plots were located in the Taber district, 7 in the Lethbridge Northern district and 3 in the United district.

Climatic Conditions.—The precipitation during April and May in the eastern part of the Lethbridge Northern district was not sufficient to ensure germination of the seed. Some crops remained ungerminated for three weeks after seeding. This condition was more prevalent on fields that had no reserve store of moisture either from fallow or previous irrigation than on fields that had either been irrigated or fallowed in 1923.

The precipitation during June varied from 3 inches in the eastern area of the Lethbridge Northern to 7 inches in the Southern United district. Irrigations were applied according to schedule, except in the United district where the precipitation during June was ample to provide for the crop. Here from 1 to 2 scheduled irrigations were cancelled.

The precipitation during July was very light in all 3 districts and especially so around the eastern portion of the Lethbridge Northern. Many fields not being irrigated in time, burned so that the crop was damaged beyond recovery.

Farmers who had intended irrigating in June deferred watering when the June rains came and still hoping for additional rain in July waited too long and were caught by the drought.

Some damage was done during the month by heavy winds which shattered the grain.

In general, for the country northeast of Lethbridge, the season was too dry for proper germination in April and May, relieved somewhat by June rains which were just heavy enough to mislead the farmer into discontinuing irrigation, and again so hot and dry in July as to burn up unwatered crops. In the United district these adverse conditions were not so severe and many excellent crops were produced on non-irrigated land.

Discussion of Results Obtained.—The following table shows the irrigation treatment and yields obtained on the demonstration plots operated during 1924:—

Results from Farm Demonstration Plots in 1924

Plot No.	District	Location	Plot area including laterals	Irrigation applied	Rainfall seeding to harvest	Total depth of water received	Total depth of water used	Yield in bushels per acre	Per acre increase in yield over non-irrigated portion of field	Remarks
					inches	inches	inches	oats	bush.	
1	Taber............	H. J. Scott...	SE. 1-10-16.	3x4½=13½"...	8	21½	22	60·6	....	
2	"	Cook Bros....	NW 20-9-16	3x4½=13½"...	8	......	......	....	....	Hailed out completely.
								wheat		
3	Lethbridge Northern.	I. Darres.....	NE35-10-20	4x4½=18"...	6	24	27	27·0	22	Sandy soil 3 years after fallow.
4	" "	C. Oseen......	SE30-11-19.	4x4½=18"...	6	24	30	50·4	35	Loam soil. Fallow in 1923.
5	" "	G. F. Foster..	NE. 8-11-21	4x4½=18"—.	6	24	14	33·6	25	Loam soil. Fallow in 1921.
6	" "	E. Dixon.....	NW.34-9-22	2-3-4½=14".	6	20	25	31·9	25	Loam soil. Fallow in 1923.
7	" "	R. Urch......	NW.34-9-23	8-6-6=20"..	8	28	23	26·5	25	Sandy soil. Broke in 1922.
8	" "	K. Poleman..	SE.28-10-25	2x4½=9"....	10	19	24	21·5	18	Loam soil. Fallow in 1923.
9	" "	C. Grier......	NW.28-9-26	Not irrigated.	......	......	......	....	....	This plot was abandoned.
10	United...........	W. B. Hovis..	NW.34-5-26	3x4=12"....	12	24	24	40·5	10	Loam soil. Fallow in 1923.
11	"	B. Quinton...	NE.33-4-27.	3x4=12"....	12	24	25	41·2	10	Loam soil. Fallow in 1923.
12	"	J. B. Merrill..	NE. 7-4-27.	1x4=4"...—	16	20	24	28·9	5	50 per cent wild oats in crop.
	Average......	....	....	....	......	......	24			

The applications of the correct amount of water produced yields of wheat varying from 26.5 to 50.4 bushels per acre. These yields were from 5 to 35 bushels per acre in excess of the yields obtained from the non-irrigated portions of the plots. In the United district, which received during the growing season a precipitation of 12 to 16 inches, the yields obtained were only 5 or 10 bushels in excess of the yields produced on the non-irrigated portions of the plot, but farther north and east, around the eastern portion of the Lethbridge Northern district, where the rainfall was only 5 or 6 inches, the plots produced from 25 to 35 bushels more per acre than the non-irrigated portions.

The yields produced under the correct irrigation treatment varied from 26.5 bushels on a light soil that had been cropped two or three times since fallowing, and on which the available fertility had been considerably depleted, up to 50.4 bushels where the crop followed summer-fallow on fertile soil. This variation in yield was due principally to the varying conditions of soil fertility and not to a lack or excess of water.

Plot No. 4, on the farm of C. Oseen, is an outstanding example of the value of irrigation demonstration work. This plot of 5 acres forms part of a 30-acre field which was high in fertility due to being summer-fallowed in 1923 and which needed only the application of the correct amount of water to enable it to produce abundantly. The first 4½-inch irrigation to the plot was applied May 27, followed by irrigations of similar depth of June 12, June 30, and July 16. Mr. Oseen was unable to apply the first irrigation to the remaining 25 acres until about June 10, and due to the demands upon his time and the lack of sufficient help, was able to apply only 1 additional irrigation. As a result of these 2 applications, which would total approximately 12 inches, he produced 43 bushels per acre from the 25 acres. Portions of this same field which he was unable to irrigate yielded approximately 15 bushels per acre. Mr. Oseen was unable

to secure help enough to follow exactly the treatment accorded the demonstration plot, but, realizing the value of the treatment, followed it as closely as possible and harvested a crop but 7 bushels per acre less than that of the demonstration plot and 28 bushels per acre more than was produced on the non-irrigated summer-fallow. This plot work has not only benefited Mr. Oseen but has served as a valuable demonstration to all his neighbours.

The average yield of 10 irrigated wheat fields in this same district was 14.4 bushels per acre. They were irrigated once only and this 1 irrigation was applied too late—after irreparable damage had been done by drought. The average production of 10 fields which were not irrigated was 4 bushels per acre. Non-irrigated summer-fallow produced approximately: 11 bushels per acre in eastern part of L. N. district near Turin; 22 bushels per acre in western part of L. N. district near Macleod; 40 bushels per acre in united district near Glenwoodville.

Report on Duty of Water Investigations for 1924

Brooks Irrigation Experiment Station

Climatology

Climatic conditions at Brooks during the season of 1924 varied considerably from normal, particularly in respect to temperature and rainfall distribution. Precipitation during the preceding winter months was very light, and where irrigation was not used in sufficient quantity, soil moisture content was very low. Moreover, temperatures during April, June and August were low and presented an uncontrollable though important limiting factor of plant growth, which was very backward during the first part of the season. With higher temperatures in July, and September, however, and a particularly long growing season, normal yields of most crops were made possible. Corn was one notable exception, but even this crop produced a fair amount of mature seed in the lighter soils. The dry, cold spring proved detrimental in obtaining satisfactory stands of sugar beets and as a result yields were low. The per cent sugar, however, was high. Alfalfa seed yields show wide variations. The rains in August were probably the cause of reduced yields in many cases.

The frost-free period for the season was very short, while the killing frost-free period was exceptionally long, extending from May 6, to October 10, a period of 157 days. The temperature records show a total monthly mean deviation of minus 9.06 degrees and a plus deviation of only 3.18 degrees or a net minus deviation of 5.88 degrees. Evaporation was correspondingly low, while total precipitation was near average. The distribution was not favourable.

The following table shows temperature, evaporatioin and precipitation records at Brooks from April to September, inclusive, 1924. Deviations from average are shown:—

Months	Temperatures					Evaporation			Precipitation		
	Maximum	Minimum	Mean	Deviation from average 1915–1923		Total inches	Deviation from average 1918–1923		Total inches	Deviation from average 1915–1923	
	°	°	°	°	°						
April	52·0	27·3	39·6	....	−2·68	3·18	+·28	....	0·46	....	−·51
May	68·0	35·5	51·8	+·57	....	5·24	....	−·11	1·05	+·05	......
June	71·0	43·8	57·4	....	−3·5	3·97	....	−1·87	1·50	....	−·45
July	83·2	51·4	67·3	+·55	....	6·24	....	−·20	1·26	....	−·20
August	75·3	48·1	61·7	....	−2·88	3·24	....	−2·00	2·41	+·77	....
September	72·5	38·8	55·7	+2·06	....	2·53	....	−·85	·86	....	−·22
	70·3	40·8	55·6	+3·18 Net=	−9·06 −5·88	24·40	+·28 Net=	−5·03 −4·75	7·54	+·82 Net=	−1·38 −·56

April.—Owing to very light winter precipitation and comparatively high evaporation, soil conditions were exceedingly dry at the beginning of April. As the records indicate, these conditions continued throughout the month. In addition to drought, low temperatures prevailed. Nights were cold as is indicated by the low mean minimum of 27.3 degrees. Frost occurred on 25 days during the month. Cloudy weather and chilling winds were prevalent. Southwest winds prevailed to some extent and produced a few warm days. Drought and low temperatures were chief factors limiting plant growth, which was noticeably below normal for this month.

May.—Weather conditions during May as indicated by evaporation, precipitation and temperature, were very near normal. A normal May precipitation was far too light, however, to restore the moisture content of the dry soil to the point required for best growth or even complete germination. Moisture stored from irrigations of the previous season proved exceedingly valuable. Where irrigation had not been used plant growth was slow and uneven. Conditions were partly relieved on the 28th, when 0.82 inch of rainfall was received. The temperature record indicated warm days and cool nights and such was the case. Frost occurred on 7 days during the first 13 days of the month. The last spring killing frost occurred on the 6th, when 16.5 degrees of frost was recorded.

June.—The weather during June was characterized chiefly by cloudiness, low temperatures and scanty rainfall. Frequent showers did occur during the month, but in quantities too small to be of much use for plant growth. Two fairly good showers were received during the latter part of the month. Both mean maximum and mean minimum temperatures were low, indicating generally cool conditions. Growth of various crops at the end of the month was from 1 to 3 weeks late.

July.—Weather conditions during July were favourable and where moisture was available plant growth was rapid. The first 20 days of the month were bright and sunny, the last part of the month was quite cloudy and rainy, though fairly high temperatures continued. The highest temperature of the season, *i.e.* 98.5 degrees was recorded on the 3rd. A freezing temperature was recorded on the 11th; this was only a dip, however, induced by a very chilling northwest wind. No perceptible damage was done. Crops generally recovered to a marked extent from the backward conditions which obtained earlier in the season. A very heavy downpour of rain occurred on the 28th, when 0.84 inch of water fell within a period of 30 minutes.

August.—Weather conditions during August varied considerably from normal. Precipitation was high and temperatures and evaporation were correspondingly low. The rainy weather reported for the latter part of July continued during the first 8 days of August. During this time 1.89 inches of rainfall was received. Favourable growing and harvest weather prevailed throughout the greater part of the month.

September.—Climatic conditions during September showed certain favourable variation from normal, particularly in respect to temperature. No killing frost occurred during the month and growing conditions were very fair. Because of the lateness of many crops in the district this was most fortunate. Freezing temperatures were recorded on 5 days on and after the 20th of the month.

October.—Weather conditions during the first 10 days of the month were very unsettled. Frequent showers occurred during this period and on the 9th, 4 inches of snow fell. The first fall killing frost occurred on the 10th, when 20 degrees of frost was recorded. Following this heavy frost, the weather cleared up and remained so until the last few days of the month. A snowstorm occurred on the 28th, when 0.64 inch of moisture precipitated.

ROTATION SCHEDULES

Rotation Schedule.—"A"—Alfalfa 5 years—potatoes—wheat—flax.
"B"—Clover 4 years—beets—oats—wheat—oats.
"C"—Grass 3 years—potatoes—barley—wheat.
"D"—Clover 2 years—wheat—barley.
"E"—Peas—wheat—oats—barley.

During 1924 the water requirement of wheat was determined under 5 different conditions of soil fertility, namely:—

1. As the second crop following 4 years of alfalfa.
2. As the third crop following 4 years of clover.
3. As the third crop following 3 years of grass.
4. As the first crop following 2 years of clover.
5. As the first crop following 1 year of peas.

The water requirements of oats were determined under 3 conditions of fertility, barley under 3, potatoes under 2, and flax under 1.

By following this rotation schedule it is possible to have in each year, grain crops coming immediately after grains or grasses, second year after legumes and third year after legumes, thus giving an opportunity of securing data to the effect that as the soil fertility decreases, the amount of water required to produce a given yield per acre increases.

SEASON'S RESULTS

The results of the past season's work are given hereunder and in the following "Plot Series Record Sheets."

Wheat.—In rotation "A" the maximum yield, 53.6 bushels per acre, was produced under a total depth received of 2.53 feet.

In rotation "B" the maximum yield, 33.0 bushels per acre, was produced under a total depth received of 2.53 feet.

In rotation "E" the maximum yield, 49.5 bushels per acre, was produced under a total depth received of 2.56 feet.

In rotation "C" the maximum yield, 41.4 bushels per acre, was produced under a total depth received of 2.53 feet.

In rotation "D" the maximum yield, 57.3 bushels per acre, was produced under a total depth received of 1.87 feet.

Summarizing the results of the 5 wheat series it is shown that the maximum yields were produced with an average total depth received of 2.40 feet, of which 0.53 feet was received as rainfall.

The maximum yield of the 5 series, 57.3 bushels per acre, was produced on land that had been in clover for 2 years previous.

Oats.—In rotation "B 1" the maximum yield, 91.3 bushels per acre, was produced under a total depth received of 2.05 feet.

In rotation "B 2" the maximum yield, 88.7 bushels per acre, was produced under a total depth received of 1.55 feet.

In rotation "E" the maximum yield, 87.9 bushels per acre, was produced under a total depth received of 2.55 feet.

Summarizing the results of the 3 oats series it is shown that the maximum yields were produced with an average total depth received of 2.05 feet, of which 0.55 foot was rainfall.

The maximum yield of the series, 91.3 bushels per acre, was produced on land that had been in corn in 1923 and in legumes in 1922.

Barley.—In rotation "D" the maximum yield, 97.3 bushels per acre, was produced under a total depth received of 1.22 feet.

In rotation "C" the maximum yield, 67.7 bushels per acre, was produced under a total depth received of 2.55 feet.

In rotation "E" the maximum yield, 57.0 bushels per acre, was produced under a total depth received of 2.55 feet.

Summarizing the results from the 3 barley series it is shown that the maximum yields were produced under an average total depth received of 2.11 feet, of which 0.55 foot was rainfall.

The maximum yield of the 3 series, 97.3 bushels per acre, was produced on land that had been in wheat and oats in 1923 and clover in 1922 and 1921.

Flax.—No reliable data were obtained on flax this season.

Alfalfa Hay.—In rotation "A", 1920 seeding, the maximum yield, 6.65 tons per acre, was produced under a total depth received of 2.55 feet, of which 0.55 foot was rainfall.

In rotation "A", 1921 seeding, the maximum yield, 6.74 tons per acre, was produced under a total depth received of 3.05 feet, of which 0.55 foot was rainfall.

In rotation "A", 1923 seeding, the maximum yield, 5.10 tons per acre, was produced under a total depth received of 3.05 feet, of which 0.55 foot was rainfall.

Summarizing the results of the 3 seedings it is shown that the maximum yields were produced under an average total depth received of 2.88 feet.

Peas.—The maximum yield of field peas, 41.1 bushels per acre, was produced under a total depth received of 2.15 feet, of which 0.65 foot was rainfall.

Potatoes.—In rotation "A" the maximum yield, 459.8 bushels per acre, was produced under a total depth of 182 feet.

In rotation "C" the maximum yield, 302.5 bushels per acre, was produced under a total depth received of 1.82 feet, of which 0.65 foot was rainfall.

Sugar Beets.—In rotation "B" the maximum yield, 14.55 tons per acre, was produced under a total depth received of 1.83 feet, of which 0.66 foot was rainfall.

Irrigation Experiment Station, Brooks, Alberta—Wheat (Marquis) Plot Series Record, 1924

ROTATION A

Plot No.	Irrigation Date and Depth Applied in Acre-feet per Acre													Duty of Water	Rainfall April First to Harvest	Total Depth Received	Total Depth used in Growing Crop	Yield per Acre	Remarks
	May	June					July					August							
		3	16	17	23	26	4		11	18	24	5							
														Ft.	Ft.	Ft.	Ft.	Bush.	Cut
42 A	....	....	....	....	....	....	....	....	....	....	....	....	....	0·00	0·53	0·53	0·67	1·0	Sept. 8
B	....	....	0·33	....	....	....	....	....	....	....	....	....	....	0·33	0·53	0·86	0·76	3·3	" 8
C	....	....	0·33	....	....	0·34	....	....	....	....	....	....	....	0·67	0·53	1·20	1·19	33·7	" 8
D	....	0·33	....	....	0·34	....	....	....	0·33	....	....	....	....	1·00	0·53	1·53	1·56	38·7	" 8
E	....	0·33	....	....	0·34	....	....	....	0·33	....	0·34	....	....	1·34	0·53	1·87	1·94	26·2	" 8
43 A	....	0·33	....	....	0·34	....	....	....	0·33	....	0·34	0·33	....	1·67	0·53	2·20	2·07	51·6	" 8
B	....	0·33	....	0·34	....	....	0·33	....	0·34	....	0·33	0·33	....	2·00	0·53	2·53	2·09	*53·6*	" 8
C	....	....	....	0·50	....	....	0·50	....	....	....	....	....	....	1·00	0·53	1·53	1·48	42·9	" 8
D	....	0·50	....	....	....	0·50	....	....	....	....	0·50	....	....	1·50	0·53	2·03	1·89	43·8	" 8
E	....	0·50	....	....	....	0·50	....	....	....	0·50	....	0·50	....	2·00	0·53	2·53	2·21	44·1	" 8

Irriagtion Experiment Station, Brooks, Alberta—Wheat (Marquis) Plot Series Record, 1924—Con.

ROTATION B

Plot No.	Irrigation Date and Depth Applied in Acre-feet per Acre													Duty of Water	Rainfall April First to Harvest	Total Depth Received	Total Depth used in Growing Crop	Yield per Acre	Remarks
	May	June					July					August							
		3	14	16	20	26	2	9	12	18	22		6						
														Ft.	Ft.	Ft.	Ft.	Bush.	Cut
58 A														0·00	0·53	0·53	0·64	0·0	
B			0·33											0·33	0·53	0·86	0·65	13·2	
C			0·33			0·34								0·67	0·53	1·20	0·95	19·8	
D		0·33			0·34			0·33						1·00	0·53	1·53	1·17	24·3	
E		0·33			0·34			0·33			0·34			1·34	0·53	1·87	1·67	28·2	
59 A		0·33			0·34			0·33			0·34		0·33	1·67	0·53	2·20	1·99	24·9	
B		0·33		0·34			0·33		0·34		0·33		0·33	2·00	0·53	2·53	2·07	33·0	
C				0·50			0·50							1·00	0·53	1·53	1·02	20·6	
D		0·50				0·50								1·50	0·53	2·03	1·30	19·9	
E		0·50				0·50					0·50		0·50	2·00	0·53	2·53	2·11	28·1	

ROTATION C

	May	June					July					August							
	31		13	16	25		2	9	12		22	5							
87 A														0·00	0·53	0·53	......	0·7	
B			0·33											0·33	0·53	0·86	......	15·4	
C			0·33		0·34									0·67	0·53	1·20	......	21·2	
D			0·33		0·34			0·33						1·00	0·53	1·53	......	26·0	
88 D	0·33				0·34			0·33			0·34			1·33	0·53	1·86	......	27·6	
C	0·33				0·34			0·33			0·34	0·33		1·67	0·53	2·20	......	23·6	
B	0·33			0·34			0·33		0·34		0·33	0·33		2·00	0·53	2·53	......	41·4	

ROTATION D

	May	June					July					August							
		2	14	16	20	26	2	10	12	18	24		6						
74 A														0·00	0·53	0·53	0·49	0·0	
B			0·33											0·33	0·53	0·86	0·62	20·7	
C			0·33			0·34								0·67	0·53	1·20	1·10	46·6	
D		0·33			0·34			0·33						1·00	0·53	1·53	1·69	55·6	
E		0·33			0·34			0·33			0·34			1·34	0·53	1·87	1·87	57·3	
75 A		0·33			0·34			0·33			0·34		0·33	1·67	0·53	2·20	2·03	55·5	
B		0·33		0·34			0·33		0·34		0·33		0·33	2·00	0·53	2·53	2·18	51·3	
C				0·50			0·50							1·00	0·53	1·53	1·49	48·0	
D		0·50				0·50					0·50			1·50	0·53	2·03	1·64	51·7	
E		0·50				0·50				0·50			0·50	2·00	0·53	2·53	2·20	51·1	

ROTATION E

	May	June					July					August							
		3	14	18	24	27	5	9	12	17	23		6						
32														0·00	0·53	0·53	......	0·0	Aug. 27
31			0·33											0·33	0·53	0·86	0·86	13·7	" 27
36			0·33			0·34								0·67	0·53	1·20	1·10	22·8	" 27
37		0·33			0·34				0·33					1·00	0·56	1·56	1·50	36·6	Sept. 8
38		0·33			0·34				0·33		0·34			1·34	0·56	1·90	1·57	40·8	" 8
39		0·33			0·34			0·33			0·34		0·33	1·67	0·56	2·23	2·15	42·8	" 3
40		0·33		0·33			0·33		0·34		0·33		0·34	2·00	0·56	2·56	2·30	49·5	" 3
33			0·50				0·50							1·00	0·56	1·56	1·56	30·7	" 8
34		0·50				0·50					0·50			1·50	0·56	2·06	1·88	37·6	" 8
35		0·50				0·50				0·50			0·50	2·00	0·53	2·53	2·39	47·4	Aug. 27

Irrigation Experiment Station, Brooks, Alberta Oats (Banner) Plot Series Record, 1924.

ROTATION B-1

Plot No.	Irrigation Date and Depth applied in Acre-feet per Acre: May	June 3	June 14	June 18	June 25	June 28	July 2	July 9	July 12	July	July 23	August	August 6	Duty of Water	Rainfall April 1 to Harvest	Total Depth Received	Total Depth used in Growing Crop	Yield per Acre	Remarks
														Ft.	Ft.	Ft.	Ft.	Bush.	
60 A														0·00	0·55	0·55	0·55e	0·0	Sept. 2
B			0·33											0·33	0·55	0·88	0·88e	31·6	" 2
C			0·33		0·34									0·67	0·55	1·22	1·18	54·0	" 2
D		0·33			0·34			0·33						1·00	0·55	1·55	1·54	63·9	" 2
E		0·33		0·34				0·33			0·34			1·34	0·55	1·89	1·86	76·7	" 2
61 A		0·33		0·34				0·33			0·33		0·34	1·67	0·55	2·22	1·50	60·4	" 2
B		0·33		0·34			0·33		0·34		0·33		0·33	2·00	0·55	2·55	1·70	80·4	" 2
C		0·50					0·50							1·00	0·55	1·55	1·60	71·2	" 2
D		0·50				0·50					0·50			1·50	0·55	2·05	2·00e	*91·3*	" 2

e Estimated.

ROTATION B-2

	May 31	June	June 13	June 18	June 25	June 28	July 3	July 10	July 14	July	July 24	August 5	August 6						
72 A														0·00	0·55	0·55	0·45	1·0	Sept. 3
B			0·33											0·33	0·55	0·88	0·85	20·8	" 3
C			0·33		0·34									0·67	0·55	1·22	0·60	61·8	Aug. 28
D	0·33			0·34				0·33						1·00	0·55	1·55	1·20	66·4	" 28
E	0·33			0·34				0·33			0·34			1·34	0·55	1·89	1·18	70·2	" 28
73 A	0·33			0·34				0·33			0·34		0·33	1·67	0·55	2·22	1·60	85·6	" 28
B	0·33			0·34			0·33		0·34		0·33		0·33	2·00	0·55	2·55	2·14	80·9	" 28
C			0·50				0·50							1·00	0·55	1·55	1·04	*88·7*	" 28
D	0·50					0·50					0·50			1·50	0·55	2·05	1·64	76·4	" 23
E	0·50				0·50							0·50		2·00	0·55	2·55	1·81	70·5	" 28

ROTATION E

	May	June 3	June 6	June 16	June 23	June 26	July 5	July	July 12	July 18	July 22	August 5	August						
7 B														0·00	0·55	0·55	0·55	0·0	Sept. 3
6				0·33										0·33	0·55	0·88	0·72	23·6	" 3
5				0·33		0·34								0·67	0·55	1·22	1·13	46·0	" 3
4		0·33			0·34				0·33					1·00	0·55	1·55	1·69	70·6	" 3
3		0·33			0·34				0·33		0·34			1·34	0·55	1·89	1·65	79·7	Aug. 22
2		0·33			0·34				0·33		0·34	0·33		1·67	0·55	2·22	1·90	82·4	" 22
1		0·33		0·34			0·33		0·34		0·33	0·33		2·00	0·55	2·55	2·23	*87·9*	" 22
10				0·50			0·50							1·00	0·55	1·55	1·58	63·3	" 22
9		0·50				0·50					0·50			1·50	0·55	2·05	1·73	61·0	" 22
8		0·50				0·50				0·50		0·50		2·00	0·55	2·55	2·38	69·3	" 22

Irrigation Experiment Station, Brooks, Alberta—Barley (Barks)—Plot Series Record, 1924

ROTATION C

PLOT SERIES RECORD

Plot No.	Irrigation Date and Depth Applied in Acre-feet per Acre													Duty of Water	Rainfall April First to Harvest	Total Depth Received	Total Depth used in Growing Crop	Yield per Acre	Remarks
	May	June					July					August							
		6	13	20	25	28	3	9	12		22	5		Ft.	Ft.	Ft.	Ft.	Bush.	
8990 A																			
B			0·33											0·33	0·55	0·88	1·04	11·3	Sept. 9
C			0·33		0·34									0·67	0·55	1·22	1·09	25·9	" 9
D		0·33			0·34			0·34						1·00	0·55	1·55	1·42	53·0	" 9
E		0·33			0·34			0·33			0·34			1·34	0·55	1·89	1·77	59·6	" 9
F		0·33			0·34			0·33			0·34	0·33		1·67	0·55	2·22	1·45	66·9	" 9
G		0·33		0·34			0·33		0·34		0·33	0·33		2·00	0·55	2·55	1·78	*67·7*	" 9
H		0·50					0·50							1·00	0·55	1·55	1·68	42·8	" 9
J		0·50					0·50				0·50			1·50	0·55	2·05	......	67·0	" 9

ROTATION D

	May	June					July					August							
		6	14		20	26	2	9	12	18	22		6						
82														0·00	0·55	0·55	0·55	0·0	Sept. 2
80 A			0·33											0·33	0·55	0·88	1·34	62·5	" 2
B			0·33			0·34								0·67	0·55	1·22	1·34	*97·3*	" 2
81 A		0·33				0·34		0·33						1·00	0·55	1·55	1·47	79·3	" 2
B		0·33				0·34		0·33			0·34			1·34	0·55	1·89	1·38	70·7	" 2
C		0·33				0·34		0·33			0·34		0·33	1·67	0·55	2·22	2·15	62·5	" 2
D		0·33			0·33		0·34		0·33		0·34		0·33	2·00	0·55	2·55	2·45	62·2	" 2
E			0·50				0·50							1·00	0·55	1·55	1·67	58·4	" 2
F		0·50					0·50				0·50			1·50	0·55	2·05	1·01	70·8	" 2
G		0·50				0·50				0·50			0·50	2·00	0·55	2·55	2·55	42·5	" 2

ROTATION E

	May	June					July					August							
		6		16	23	26	4		11	18	22	5							
14 B														0·00	0·55	0·55	1·42	0·0	
15				0·33										0·33	0·55	0·88	0·68	7·5	
16				0·33		0·34								0·67	0·55	1·22	0·90	34·8	
17		0·33				0·34			0·33					1·00	0·55	1·55	1·45	47·5	
18		0·33				0·34			0·33		0·34			1·34	0·55	1·89	1·50	48·7	
19		0·33				0·34			0·33		0·34	0·33		1·67	0·55	2·22	2·30	51·0	
20		0·33			0·34		0·33		0·34		0·33	0·33		2·00	0·55	2·55	2·48	*57·0*	
11				0·50			0·50							1·00	0·55	1·55	1·51	40·1	
12		0·50					0·50				0·50			1·50	0·55	2·05	1·97	45·4	
13		0·50				0·50				0·50		0·50		2·00	0·55	2·55	2·43	50·7	

Irrigation Experiment Station, Brooks, Alberta—Alfalfa (Grimm) Plot Series Record, 1924

ROTATION A, 1920 SEEDING

Plot No.	Irrigation Date and Depth Applied in Acre-feet per Acre: May 16	May 20	May 29	June 5	June 10	June 23	June 25	July 5	July 10	July 18	July 25	Aug. 9	Duty of Water	Rainfall April First to Harvest	Total Depth Received	Total Depth used in Growing Crop	Yield per Acre	Remarks
													Ft.	Ft.	Ft.	Ft.	Lbs.	Cut
46 A													0·00	0·55	0·55	0·72	0·63	Aug. 18
B					0·50								0·50	0·55	1·05	0·98	2·44	
C				0·50					0·50				1·00	0·55	1·55	1·28	3·23	
D			0·50				0·50			0·50			1·50	0·55	2·05	1·60	5·53	
E		0·50			0·50			0·50		0·50			2·00	0·55	2·55	1·94	*6·65*	
47 A	0·50				0·50		0·50		0·50		0·50		2·50	0·55	3·05	2·26	6·08	
B	0·50				0·50		0·50		0·50		0·50	0·50	3·00	0·55	3·55	2·87	5·79	
C	0·33				0·34			0·33		0·34			1·34	0·55	1·89	1·57	5·15	
D	0·33				0·34		0·33		0·34		0·33		1·67	0·55	2·22	1·63	5·57	
E	0·33				0·34		0·33		0·34		0·33	0·33	2·00	0·55	2·55	2·02	5·55	

ROTATION A, 1921 SEEDING

Plot No.	May 17	May 29	June 5	June 10	June 20	June 25	July 5	July 8	July 11	July 18	July 25	Aug. 9	Duty of Water	Rainfall April First to Harvest	Total Depth Received	Total Depth used in Growing Crop	Yield per Acre	Remarks
48 A													0·00	0·55	0·55	0·47	0·05	Cut Aug. 18
B				0·50									0·50	0·55	1·05	0·83	1·01	
C			0·50					0·50					1·00	0·55	1·55	1·40	3·62	
D		0·50			0·50					0·50			1·50	0·55	2·05	1·46	5·55	
E	0·50			0·50			0·50			0·50			2·00	0·55	2·55	1·93	6·00	
49 A	0·50			0·50		0·50			0·50		0·50		2·50	0·55	3·05	2·81	*6·74*	
B	0·50			0·50		0·50			0·50		0·50	0·50	3·00	0·55	3·55	3·19	6·40	
C	0·33			0·33			0·33			0·34			1·33	0·55	1·88	1·70	5·46	
D	0·33			0·33		0·34			0·33		0·34		1·67	0·55	2·22	2·22	5·45	
E	0·50			0·50		0·33			0·34		0·33	0·34	2·34	0·55	2·89	2·52	6·03	

ROTATION A, 1923 SEEDING

Plot No.	May 17	May 29	June 5	June 11	June 20	June 25	July 5	July 10	July 18	July 26	Aug. 9	Duty of Water	Rainfall April First to Harvest	Total Depth Received	Total Depth used in Growing Crop	Yield per Acre	Remarks
52 A												0·00	0·55	0·55	0·59	1·82	Cut Aug. 18
B				0·50								0·50	0·55	1·05	1·29	2·19	
C			0·50					0·50				1·00	0·55	1·55	1·43	2·77	
D		0·50			0·50				0·50			1·50	0·55	2·05	1·60	2·22	
53 A	0·50			0·50			0·50		0·50			2·00	0·55	2·55	2·20	4·55	
B	0·50			0·50		0·50		0·50		0·50		2·50	0·55	3·05	2·87	*5·10*	
C	0·50			0·50		0·50		0·50		0·50	0·50	3·00	0·55	3·55	3·18	4·48	

Irrigation Experiment Station, Brooks, Alberta—Peas (Prussian Blue)—Plot Series Record, 1924

ROTATION E

Plot No.	Irrigation Date and Depth Applied in Acre-feet per Acre: May 30	June 3	June 14	June 17	June 23	June 27	July 4	July 10	July 14	July 17	July 23	July 25	Aug. 5	Duty of water	Rainfall April First to Harvest	Total Depth Received	Total Depth used in Growing Crop	Yield per Acre	Remarks
														Ft.	Ft.	Ft.	Ft.	Bush.	
30 A														0·00	0·57	0·57	0·57	0·0	Sept. 16
26			0·33											0·33	0·57	0·90	0·95	8·0	" 16
25			0·33			0·34								0·67	0·57	1·24	1·33	24·6	" 16
24	0·33			0·34				0·33						1·00	0·57	1·57	1·62	32·6	" 16
23	0·33			0·34				0·33			0·34			1·34	0·65	1·99	2·01	39·5	Oct. 8
22	0·33			0·34				0·33			0·34		0·33	1·67	0·65	2·32	2·31	35·4	" 8
21 A	0·33			0·34			0·33		0·34		0·33		0·33	2·00	0·61	2·61	2·40	24·2	Sept. 22
21 B	0·33			0·34		0·33		0·34		0·33		0·34	0·33	2·34	0·61	2·95	3·10	24·4	" 22
30				0·50			0·50							1·00	0·57	1·57	1·67	38·8	" 16
29		0·50				0·50					0·50			1·50	0·65	2·15	2·31	*41·1*	Oct. 8
28		0·50				0·50				0·50			0·50	2·00	0·65	2·65	2·70	36·8	" 8

Irrigation Experiment Station, Brooks, Alberta—Potatoes (Netted Gem)—Plot Series Record, 1924

ROTATION A

Plot No.	Irrigation Date and Depth Applied in Acre-feet per Acre									Duty of Water	Rainfall April First to Harvest	Total Depth Received	Total Depth used in Growing Crop	Yield per Acre	
	July				August				Sept.					No. 1	No. 2
	7	15	24	30	5	15	19	25	1						
										Ft.	Ft.	Ft.	Ft.	Bush.	Bush.
44 A	....	....	....	....	....	....	....	....	......	0·00	0·65	0·65	0·50	48·0	27·8
B	....	0·33	....	....	....	....	....	....	......	0·33	0·65	0·98	1·11	259·4	25·9
C	....	0·33	....	....	0·17	....	....	....	......	0·50	0·65	1·15	1·12	193·5	23·4
D	0·17	0·33	....	....	0·17	....	....	....	......	0·67	0·65	1·32	1·27	272·6	24·8
E	0·17	0·33	....	....	0·17	....	....	0·17	......	0·84	0·65	1·49	1·50	410·0	18·5
45 A	0·17	0·33	....	0·17	....	0·17	....	0·17	......	1·01	0·65	1·66	1·59	415·0	13·4
B	0·17	0·33	0·17	....	0·17	....	0·17	....	0·17	1·18	0·65	1·83	1·77	444·7	13·8
C	....	0·42	....	....	....	0·25	....	....	......	0·67	0·65	1·32	1·20	303·9	30·8
D	0·25	0·42	....	....	....	0·25	....	....	......	0·92	0·65	1·57	1·41	419·5	28·8
E	0·25	0·42	....	....	....	0·25	....	0·25	......	1·17	0·65	1·82	1·66	*459·8*	13·4

ROTATION C

	July			August											
	7	15	26	5	15	19	25	30							
														No. 1	No. 2
92 A	0·17	....	....	....	....	....	....	....	......	0·17	0·65	0·82	0·80	144·2	20·9
B	....	0·33	....	....	....	....	....	....	......	0·33	0·65	0·98	0·67	134·9	14·9
C	....	0·33	....	0·17	....	....	....	....	......	0·50	0·65	1·15	1·18	250·3	7·0
D	0·17	0·33	....	0·17	....	....	....	....	......	0·67	0·65	1·32	1·37	294·9	13·1
91 A	0·17	0·33	....	0·17	....	....	0·17	....	......	0·84	0·65	1·49	1·33	236·9	13·4
B	0·17	0·33	0·17	....	0·17	....	0·17	....	......	1·01	0·65	1·66	1·78	248·0	20·2
C	0·17	0·33	0·17	0·17	....	0·17	....	0·17	......	1·18	0·65	1·83	1·70	278·2	9·6
D	....	0·42	....	....	0·25	....	....	....	......	0·67	0·65	1·32	1·18	168·7	16·8
E	0·25	0·42	....	....	0·25	....	....	....	......	0·92	0·65	1·57	1·73	282·6	17·4
F	0·25	0·42	....	....	0·25	....	0·25	....	......	1·17	0·65	1·82	1·77	*302·5*	23·6

Table showing comparisons between Coaldale, Brooks, Strathmore and Ronalane for Temperature, Evaporation and Precipitation

NW. 25-8-20—COALDALE El. 2828·1

—	Evaporation										Monthly and seasonal averages, 1915–1924
	1915	1916	1917	1918	1919	1920	1921	1922	1923	1924	
April	5·68	1·51	2·55	3·20	6·59	3·31	2·05	1·97	3·19	2·77	3·58
May	4·28	5·12	4·83	6·76	5·20	5·68	3·69	4·32	4·63	4·32	4·88
June	2·26	4·68	5·78	7·88	7·30	6·47	6·62	5·17	3·30	3·60	5·31
July	4·38	6·20	9·20	7·68	8·12	6·92	6·55	5·45	4·42	5·67	6·46
August	4·97	4·70	5·23	6·79	6·91	5·76	6·09	5·42	3·90	4·03	5·38
September	2·92	3·59	4·35	3·78	3·81	4·80	4·28	4·40	3·85	3·61	3·94
Sums	24·50	25·80	31·94	36·07	37·93	32·95	29·28	26·73	23·29	24·00	29·55
	Precipitation										
April	0·00	0·26	0·70	0·15	0·53	3·54	0·54	2·93	1·12	0·45	1·02
May	2·99	4·12	0·86	1·03	1·86	1·59	1·28	1·28	3·16	0·82	1·90
June	5·31	3·82	2·11	0·65	0·66	1·09	0·86	1·24	3·51	3·22	2·25
July	5·15	2·47	0·29	0·93	1·27	3·21	2·17	2·25	3·18	0·75	2·17
August	0·28	3·25	1·88	1·23	1·20	0·20	0·55	0·33	1·30	3·14	1·34
September	2·11	4·79	2·82	0·41	2·14	0·31	0·21	0·73	0·09	1·23	1·58
Sums	15·84	18·71	8·66	4·40	7·66	10·03	6·61	8·76	12·36	9·61	10·26
	Temperature										
April	50·0	44·2	39·2	42·8	45·4	31·1	41·2	38·2	41·4	41·3	41·5
May	51·1	48·6	49·7	44·0	49·0	47·6	51·0	51·6	53·2	53·5	49·9
June	54·7	56·4	56·4	63·0	58·3	57·0	62·8	61·7	60·6	56·0	58·7
July	59·3	63·3	68·5	64·3	65·9	69·0	64·6	64·0	66·5	65·1	65·0
August	67·2	60·8	63·5	63·5	66·7	68·1	62·7	66·0	63·3	60·3	64·2
September	50·4	53·6	55·1	57·4	54·8	55·4	50·3	59·0	56·5	55·8	54·8
Averages	55·4	54·5	55·4	55·8	56·7	54·7	55·4	56·8	56·9	55·3	55·7

Table showing comparisons between Coaldale, Brooks, Strathmore and Ronalane for Temperature, Evaporation and Precipitation—Con.

SE. 6-19-14—BROOKS El. 2455

—	Evaporation										Monthly and seasonal averages, 1915–1924
	1915	1916	1917	1918	1919	1920	1921	1922	1923	1924	
April	....	....	....	5·68	2·47	1·05	2·64	1·71	3·73	3·16	2·92
May	....	....	....	8·47	6·07	4·28	3·69	4·73	4·89	5·24	5·34
June	....	....	....	8·50	7·33	5·73	5·77	4·52	3·22	3·97	5·58
July	....	....	....	9·57	7·15	5·15	6·29	5·35	5·13	6·24	6·41
August	....	....	....	6·80	5·21	5·65	6·01	4·64	3·18	3·24	4·96
September	....	....	....	3·84	3·21	4·12	3·22	2·82	3·12	2·53	3·26
Sums	....	....	....	42·86	31·44	25·98	27·62	23·77	23·27	24·38	28·47

	Precipitation										
April	....	....	0·58	0·00	1·41	1·16	0·95	1·94	0·78	0·46	0·91
May	....	....	1·01	0·42	1·02	0·88	1·55	1·26	0·90	1·05	1·01
June	5·41	2·27	0·89	0·54	0·40	1·52	0·21	2·09	4·19	1·50	1·90
July	1·55	2·61	1·06	1·39	1·46	1·41	1·44	0·33	1·87	1·26	1·44
August	2·07	1·80	2·45	1·15	2·40	0·00	1·46	1·70	1·75	2·41	1·72
September	0·65	2·45	0·82	0·31	1·77	0·00	2·65	1·12	0·00	0·86	1·06
Sums	....	....	6·81	3·81	8·46	4·97	8·26	8·44	9·49	7·54	8·04

	Temperature										
April	48·2	43·0	39·0	46·0	43·8	34·6	41·5	41·0	43·4	39·6	42·0
May	50·0	47·0	52·0	52·0	53·1	50·8	50·3	52·7	53·2	51·8	51·3
June	56·4	58·0	58·3	65·0	62·4	59·4	64·6	62·2	61·9	57·4	60·6
July	62·0	66·0	70·5	67·5	66·3	69·0	67·3	64·9	67·3	67·3	66·8
August	70·0	62·0	63·9	64·2	64·5	64·6	63·2	65·6	63·2	61·7	64·3
September	51·0	52·0	54·3	53·2	54·8	55·5	50·0	57·0	55·0	55·7	53·8
Averages	56·3	54·7	56·3	58·0	57·5	55·6	56·1	57·2	57·3	55·5	56·46

NE. 11-24-25—STRATHMORE El. 3190

—	Evaporation										Monthly and seasonal averages, 1915–1924
	1915	1916	1917	1918	1919	1920	1921	1922	1923	2924	
April	4·22	2·59	2·09	2·88	4·15	2·05	3·00	....	3·69	1·80	2·94
May	4·73	3·46	3·70	4·58	6·42	3·00	4·76	5·85	5·43	4·78	4·67
June	4·33	4·59	4·60	5·83	6·42	4·20	6·02	4·24	3·50	3·81	4·75
July	6·47	4·84	5·88	6·13	5·46	4·47	6·27	5·33	4·76	4·44	5·40
August	4·25	3·16	3·66	4·01	3·65	4·47	3·59	3·74	3·37	3·20	3·71
September	2·27	2·66	2·27	2·62	1·64	3·67	2·69	3·56	2·44	2·89	2·67
Sums	26·27	21·30	22·20	26·05	27·74	21·86	26·33	....	23·19	20·92	24·14

	Precipitation										
April	0·11	0·44	0·56	0·39	1·45	2·11	1·28	2·71	1·06	1·09	1·12
May	3·42	4·51	3·26	1·08	2·26	1·78	0·71	0·36	3·97	0·55	2·19
June	4·77	2·02	2·30	0·22	1·10	1·72	1·14	1·30	4·02	4·00	2·26
July	4·89	3·42	0·51	1·10	1·56	2·87	2·70	2·15	2·56	1·08	2·28
August	1·48	3·13	2·48	2·10	3·46	0·27	2·99	2·73	1·98	2·19	2·28
September	2·56	2·60	1·05	0·82	3·26	0·08	0·63	0·76	0·83	0·98	1·36
Sums	17·23	16·12	10·16	5·71	13·09	8·83	9·44	10·01	14·42	9·89	11·49

	Temperature										
April	46·0	41·0	35·1	41·2	41·9	27·7	38·6	35·7	38·5	37·0	38·3
May	48·6	44·4	47·2	48·5	47·4	46·0	49·2	50·2	49·8	51·4	48·3
June	51·7	53·9	54·2	59·9	56·1	55·5	60·3	54·2	54·0	54·1	55·4
July	57·2	59·1	64·9	62·6	61·7	65·0	61·8	60·7	62·3	63·3	61·9
August	64·4	56·7	59·0	55·5	60·4	60·8	58·9	61·9	59·5	58·0	59·5
September	47·0	48·5	51·6	49·0	49·5	51·3	47·0	54·8	52·3	52·7	50·4
Averages	52·6	50·6	52·0	52·8	52·8	51·0	52·6	52·9	52·7	52·8	52·3

NW. 5-13-12—RONALANE El. 2330

—	Precipitation										Monthly and seasonal averages, 1915–1924
	1915	1916	1917	1918	1919	1920	1921	1922	1923	1924	
April	0·09	0·14	0·84	0·21	2·34	0·90	0·62	2·48	0·93	0·17	0·87
May	1·69	2·33	0·76	0·65	1·62	1·54	1·74	0·80	1·63	0·56	1·33
June	4·15	4·32	1·29	1·22	0·37	0·66	0·74	1·73	5·12	1·63	2·12
July	3·26	4·24	0·24	1·37	0·89	2·22	1·21	1·10	2·34	0·69	1·76
August	0·75	1·68	1·34	0·92	0·77	0·00	0·57	0·48	1·32	3·00	1·08
September	1·29	3·14	1·53	0·22	0·83	0·03	1·96	0·59	0·00	0·77	1·04
Sums	1·23	15·85	6·00	4·59	6·82	5·35	6·83	7·18	11·34	6·82	8·20
	Temperature										
April	51·4	43·9	57·7	42·2	45·5	33·6	42·9	41·1	40·57	40·13	43·90
May	53·0	48·7	51·6	49·8	53·6	50·4	52·4	54·0	54·10	52·04	51·96
June	56·4	57·6	57·8	64·1	63·1	50·7	66·3	60·3	61·68	56·16	60·31
July	61·2	65·8	69·9	65·0	67·3	69·5	68·3	66·7	67·82	66·09	66·76
August	69·2	62·1	62·6	64·4	66·6	65·8	64·8	68·3	63·35	60·48	64·76
September	51·5	53·3	55·1	55·0	54·6	56·9	50·7	61·5	54·90	55·48	54·90
Averages	57·1	55·2	55·8	56·8	58·4	56·0	57·6	58·6	57·07	55·06	57·10

Summary of Temperature, Precipitation and Evaporation at Coaldale, Brooks, Strathmore and Ronalane, April to September, inclusive

Station	Mean temperature 10-year period 1915-24	Precipitation 10-year period 1915-24	Evaporation 7-year period 1918-24
	Degrees F.	Inches	Inches
Coaldale	55·7	10·26	30·03
Brooks	56·5	8·04	28·47
Strathmore	52·3	11·49	24·51
Ronalane*	57·10	8·20	....

* Records for 1924 taken at Vauxhall.

DRAINAGE

Drainage Surveys and Investigations

Drainage investigations during the year 1924-25 have been restricted very largely to the inspections and surveys of small projects. No new investigations of projects for development by the Federal Government have been made.

SMALL PROJECTS

Settlers may carrry out small drainage schemes, under the provisions of the Federal and Provincial Drainage Laws, to reclaim the balance of their holdings or to purchase for reclamation adjoining Dominion land. Such schemes shall not exceed in size 1,280 acres and in estimated cost $5,000.

The Department of the Interior makes the required engineering investigation free of charge, and annual inspections of each authorized scheme are made until the schemes are completed to the satisfaction of the minister, after which title to the reclaimed land is granted by the department. As a rule the settlers themselves undertake the actual construction of the drainage works, thus avoiding an outlay of cash. Where more than one settler is affected, they join together and share the labour entailed on the basis of their respective interests in the project.

Many shallow lakes and sloughs immediately adjoining or forming a part of established farms, formerly of no value, and very often a menace to stock, have been drained by settlers, who by means of a comparatively small expenditure of cash have been able to secure large returns from the reclaimed lands chiefly in the form of forage crops. Some 3,500 tons of cultivated hay were harvested from these small projects in the province of Alberta in addition to a large quantity of wild hay. Sixty schemes of this character were investigated or inspected this year.

PROVINCIAL SCHEMES

In connection with drainage districts organized under the Provincial Drainage Laws and Part III of the Federal Drainage Regulations, it is necessary that this department authorize the removal of any water areas affected before drainage may be undertaken. This action is essential to determine the effect of drainage on any water rights already granted under the Irrigation Act, and upon irrigation or water supply generally and their future development.

Two projects of this class were investigated by the department this year as follows:—

1. Naicam Drainage district of the province of Saskatchewan, situated in tps. 38, 39 and 40, rge. 18, W. 2nd mer. It was determined that no water rights would be prejudicially affected by the proposed scheme and authorization was accordingly granted by the department.

2. Wascana Drainage district of the province of Saskatchewan, situated in tp. 12, rges, 15 and 16, W. 2nd mer. This project is located on the height of land separating the Wascana Creek and Souris River watersheds and to determine definitely the effect of the proposed reclamation project in relation to the provisions of the Irrigation Act, it was necessary to make a more comprehensive investigation than is usually required in such cases as 2 drainage basins are involved. Some 68 miles of section line were run, of which 56 were circuited. Temporary bench-marks were established at section and quarter-section corners and a permanent bench-mark established at the NE. corner sec. 34, tp. 13, rge. 17, W. 2nd mer. The investigation disclosed conditions favourable to drainage.

DOMINION PROJECTS

Waterhen Lake Drainage District

The lake portion of this project has now been successfully drained. The water was let off in August, 1922, and practically the whole area relieved of surface water by the fall of that year. During the season of 1923 the water surface gradually lowered from an elevation near the surface to $1\frac{1}{2}$ to 3 feet below. During 1924 the water table continued to lower until it is now from 4 to 6 feet below the lake bed.

On account of the thick growth of semi-aquatic vegetation covering the marsh portion of this project, a considerable time elapsed after the construction of canals before the greater portion of the surface water was disposed of. By the fall of 1922, the water table was still near the surface and pools were found scattered over the greater portion of the area. During 1923 the water table receded very gradually to 1 or 2 feet below the surface. In 1924, however, which was an exceptionally dry season, the water table receded very rapidly and now is from 3 to 5 feet below the surface.

The greater portion of the lake bed consisting of 5,270 acres was leased in 1924, and the lessee also took over the experimental plots previously under the supervision of the department. The remaining portion of the lake bed, consisting of 570 acres, was leased to those settlers owning the fractional quarter-sections adjacent to the lake.

By employing two 20-h.p. caterpillar gasoline tractors, about 2,000 acres of the leasehold of Messrs. Balcovske and Wadlinger were prepared by disc harrowing for seeding, which was carried out by 6 seeders drawn by 6 horses each. 1,700 acres were sowed to flax, the remainder consisting of oats, wheat, barley, rye and cultivated grasses.

Early in the growing season indications pointed to a splendid crop. The flax and other grains showed well and apparently in a healthy condition. Unfortunately in July a drought, the intensity of which has never before been experienced in this district, commenced to be felt and continuing as it did through the major portion of August and September, caused a complete failure of the flax crop. The results of the other grain crops, however, compared favourably with the results of similar crops on the high lands adjoining.

The lessees of the marginal area experimented with crops other than flax and having regard to the abnormal conditions during the growing season obtained very satisfactory results.

With the experience gained this season by the lessees of the reclaimed land in Waterhen Lake bed proper, and given average meteorological conditions, it is considered that next season's crop results should compare most favourably with the high averages of returns enjoyed by this district generally.

Carrot River Reclamation Project

A general description of the Carrot river reclamation project, which has been under consideration by the department for a number of years, will be found in previous annual reports. It consists of some 1,086 square miles contained in a triangle formed by the Saskatchewan and Carrot rivers and the Sipanok channel, and an additional area of some 350 square miles adjoining this on the east, known as the Pasquia extension. This large area is not only subject to the overflow of the Saskatchewan river during unusually high water, but, owing to the fact that the general level of the larger portion of it is below water level at ordinary stages of the streams, drainage by gravity is prevented. The only method of reclaiming this area, therefore, is by a system of levees along the streams to prevent the overflow, and the installation of pumping plants to dispose of the drainage water.

A very thorough study has been made of the project and cost estimates compiled for 5 alternative schemes providing for the whole or partial reclamation of the area. That area between the Saskatchewan and Carrot rivers and the Sipanok channel has been divided into 5 districts, each with a separate canal system and pumping plant. Three of these systems drain into the Saskatchewan river and 2 into the Carrot river. The 5 schemes considered consist of various combinations of these districts and the Pasquia area which is provided with a separate canal system and pumping plant.

Scheme "A".—This scheme includes 1,086 square miles between the Saskatchewan and Carrot rivers extending as far west as the Sipanok channel and embraces all of the 5 districts referred to. An extensive system of levees is provided to prevent overflow, and drainage water is disposed of by 5 separate pumping plants. The height of the proposed levees is based on the estimated high-water grade line of the Saskatchewan, Carrot and Pasquia rivers allowing for a freeboard of 3 feet. Levees of over 11 feet in height have been designed for a crown of 10 feet and under that height for a crown of 8 feet. The side slopes adopted are 3 to 1 on the river side and 2 to 1 on the land side. In all cases a berm of 20 feet has been allowed between the toe of slope and the borrow pits. Canals have been designed for bed widths varying from 3 to 120 feet with side slopes of 1 to 1 and are of sufficient capacity to provide for a maximum runoff of 2¼ cubic feet per second per square mile of area drained.

The power required for the 5 pumping stations amounts to 6,565 h.-p. and it is found more economical to develop this power at individual stations than at one central station. The pumping plants including pumps of the centrifugal type require 2 or more units of such capacity as would show the greatest economy in operation. These pumps should be of standard size so as to provide for replacement or repair without interfering with operation.

Scheme " B ".—This scheme includes about 255 square miles extending from the mouth of the Carrot river westerly to the higher lands through the centre of rge. 31, W. Principal mer. It is bounded on the north by the Saskatchewan river and on the south by the Carrot river. To protect this area from overflow it is necessary to construct levees completely around it. The interior water courses are diverted to the Carrot river by means of the levees at the western boundary. The estimated power requirements amount to 1,795 h.-p. which is provided for by 2 separate plants.

Scheme " C ".—This scheme includes an area of about 240 square miles between the Carrot and Pasquia rivers extending from the mouth of the latter stream westerly to about the centre of rge. 31, W. Principal mer. This scheme requires a levee completely around the area to prevent overflow during high water. A single system of canals has been projected to cover the whole area and a pumping station provided at the eastern end of the district by which the drainage water is discharged in the Pasquia river at a point 2 miles above its confluence with the Saskatchewan river. In normal and high-water years, during the period that the rivers are in flood, pumping will have to be resorted to for the eastern portion of the area. Drainage water from the western portion, however, may at all times be discharged by gravity to Big Lake which forms a natural reservoir with a capacity of 22,400 acre-feet. All canals in the western portion of the district will discharge into this lake and by the construction of a hold up gate at its outlet will provide for the drainage of the western portion of the area until such time as the river subsides and the reservoir discharged by gravity. The power requirements are estimated at 935 h.-p. and are provided for by a single plant.

Scheme " D ".—This includes the total areas under schemes " A " and " C " consisting of about 1,326 square miles. The levees and canals required are similar to those designed for the above schemes. The total power requirement is 7,500 h.-p. and is provided for by 6 separate stations.

Scheme " E ".—This scheme is a combination of schemes " B " and " C " and includes the total area of both, amounitng to some 495 square miles. The system of levees and canals is similar to those provided for the above schemes.

The amount of power to be developed is about 2,730 h.p. and although the cost of a central generating plant is considerably in excess of the unit type plant, there is a very large difference in operating cost in favour of the former type. In this case, therefore, the central power station has been adopted.

This project has decided possibilities but the development is largely dependent upon the need of more farm lands for which at the present time there is not much demand. Another requirement is cheap power and to secure this it may be necessary to await hydro-electric development on the Saskatchewan river.

The following table shows the capital and annual cost of the schemes investigated and also an estimate of the power required. The costs include 10 per cent for engineering and contingencies, and also interest charges at 5 per cent to carry the scheme for 2 years during construction:—

Carrot River Reclamation Scheme—Comparison of Costs of Different Proposed Schemes

Scheme	Area, drained, acres	Capital cost	Annual cost main and Op.	Capital cost per acre	Annual cost per acre	Cost of pump plant	Cost of Pump plant per acre	Est. H.P. required	Theoretical H.P.	Per cent of theoretical to gross
		$	$	$ cts.	$ cts.	$	$ cts.			
A	659,168	6,291,656	406,255	9 05	0 58	1,215,440	1 75	6,565	4,783	75
B	163,456	2,113,555	120,580	12 93	0 74	330,485	2 02	1,795	1,296	72
C	153,525	2,177,808	87,980	14 19	0 57	197,130	1 28	935	682	73
D	848,693	8,469,531	494,235	9 98	0 58	1,412,570	1 66	7,500	5,465	73
E	316,981	4,372,740	193,670	13 79	0 61	608,925	1 92	2,730	1,978	73

PRIVATE SCHEMES

Catfish Creek Drainage Project

In connection with the Catfish Creek drainage project of the McArthur Land Company, a certain amount of drainage construction work was carried on during the summer of 1924. Work was started May 30, at the junction of the proposed channels Nos. 1 and 2 and from this point the dredge worked south along Channel No. 1 for a distance of 5,200 feet. The dredge, a floating type with a 45-foot boom, experienced difficulty owing to the falling in of the banks and on this account the work was closed down on July 30. With the lengthening of the boom to 55 feet it is expected that no further difficulty from this cause will be encountered.

Dominion Drainage Regulations

In 1917 an agreement was reached between the Governments of the Dominion and of the provinces of Saskatchewan and Alberta regarding drainage in these provinces. This agreement was subsequently ratified by the respective governments by the enacting of special legislation in the form of drainage laws and regulations.

To give full effect to the drainage agreement, having regard to the altered conditions of the present time and to the advancement made in the science of reclamation, it was felt by all interests affected that certain amendments and changes should now be made to the existing drainage acts and regulations.

Accordingly conferences between responsible officers of the department and of the drainage departments of the Provincial Governments were held in Regina, Sask., and Edmonton, Alberta, when the matter of drainage was fully discussed and revisions to the drainage agreement tentatively agreed to. Amendments to the Dominion Drainage Regulations are now being considered and when these are finally approved by the department and the provinces, will be submitted to the Dominion Government.

Special Investigations

This department co-operated with the Department of Indian Affairs by carrying out at the request of the latter a field investigation to ascertain the feasibility and probable cost of reclaiming by drainage a part of St. Anne island, situated in lake St. Clair near the mouth of the St. Clair river, comprising the Caldwell Indian reserve.

The island comprises about 6,000 acres of which it is proposed to reclaim 2,000 acres. It is low-lying and flat with a variation in elevation nowhere exceeding 2 feet within the area to be drained. It is covered with wild grass, rushes and cat-tails and is practically treeless. The interior of the drainage

area is a wide shallow basin, and is covered for the most part with about 6 inches of water, the surface of which is about 1 foot above the level of the water surface adjoining the island.

The investigation and surveys conducted by 2 engineers of the service occupied 10 days and were carried out in June 1924. The investigation proved the scheme to be a combined gravity and pumping one. Low dykes will be required to protect the district from flooding from the outside, while lateral drains leading to a sump, will discharge the interior drainage where it will be pumped over the dyke. The maximum lift for the pump will be 6 feet. The total cost of the project is estimated at $21,960 or approximately $11 per acre, which renders it economically feasible when it is considered that reclaimed land of the same character in this locality is valued at $100 per acre.

A copy of the report of the investigation and of the accompanying plans were furnished to the Department of Indian Affairs.

CLASSIFIED LIST OF PUBLICATIONS

WATER POWER

The Reports pertaining to Water Power, published by the Dominion Water Power and Reclamation Service, with the exception of the Annual Reports, have been called Water Resources Papers, and have been numbered 1, 2, etc.

Annual Reports previous to 1913 are included with the Annual Report of the Department of the Interior, and can be secured from the secretary of the department.

Annual Reports for the fiscal years ended March 31, from 1913 to 1925, are available for distribution. That for 1924 is the first report combining the activities of the Water Power and Reclamation divisions of the Service.

REPORTS OF SPECIAL OR GENERAL INTEREST

Water Resources Paper No. 2.—Report on Bow River Power and Storage Investigations, Bow river west of Calgary, by M. C. Hendry, chief engineer in charge of surveys. This is a complete study of the Bow river west of Calgary. It deals with meteorological conditions and their effect on run-off and ice formation. Existing and possible power and storage developments, together with maps and plans are appended complete. Published 1914.

Water Resources Paper No. 3.—Report on Power and Storage Investigations, Winnipeg River, by J. T. Johnston, chief hydraulic engineer, Dominion Water Power Branch. A complete study based on field surveys and office computations of the Winnipeg River basin; deals fully with history, international considerations, topography, climate, storage possibilities; describes existing and gives preliminary designs and estimates for possible power developments; discusses other source of power and the power market. Maps, plans and all relevant data are appended. Published 1915.

Water Resources Paper No. 5.—Preliminary Report on the Pasquia Reclamation Project by T. H. Dunn, chief engineer in charge of Reclamation Survey. This is a progress report of investigations carried out to determine the possibility of lowering the level of Cedar lake and its effect in a general scheme for reclaiming the low-lying lands contiguous to the Saskatchewan river in the Pasquia region. Published 1914. Out of print.

Water Resources Paper No. 6.—Report on cost of various sources of power for pumping in connection with the South Saskatchewan Water Supply Diversion Project, by H. E. M. Kensit. It deals with the problem of power for pumping water from the South Saskatchewan river for the supply of cities and towns in the central portion of south Saskatchewan. Published 1914. Out of print.

Water Resources Paper No. 7.—Report on the Manitoba Water Powers, by D. L. McLean, S. S. Scovil and J. T. Johnston, compiled for the Manitoba Public Utilities Commission. A general survey of the water-power situation in Manitoba, with all available general information and hydrometric data published to date in condensed form concerning the rivers in Manitoba. Published 1914.

Water Resources Paper No. 10.—General Guide for Compilation of Water Power Reports of Dominion Water Power Branch, prepared for the guidance of field engineers of the Dominion Water Power Branch, by J. T. Johnston, chief hydraulic engineer. Published 1915. Limited edition.

Water Resources Paper No. 11.—Second Report on the Pasquia Reclamation Project, by T. H. Dunn, chief engineer in charge of Reclamation Survey. This is a continuation Report based on further investigations as outlined under Water Resources Paper No. 5. Published 1915. Out of print.

Water Resources Paper No. 12.—Report on Small Water Powers in Western Canada, and discussion on sources of power for the Farm, by A. M. Beale. Part I is a brief description of certain small western water-power developments. Part II gives an analysis of requirements and cost data for the farm power supply. Published 1915. Out of print.

Water Resources Paper No. 13.—Report on the Coquitlam-Buntzen Hydro-Electric Development. A complete description of the project and of the details of construction, with plans, diagrams and illustrations, by G. R. G. Conway, chief engineer of the British Columbia Electric Railway Company, Limited. Published 1915.

CLASSIFIED LIST OF PUBLICATIONS—Continued

Water Resources Paper No. 16.—Water Powers of Canada. A series of five pamphlets in one volume covering the water-power situation in Canada, prepared for distribution at the Panama Pacific Exposition, San Francisco, 1915, by G. R. G. Conway, consulting engineer, Toronto; Percival H. Mitchell, consulting engineer, Toronto; H. G. Acres, hydraulic engineer, Hydro-Electric Power Commission, Ontario; F. T. Kaelin, assistant chief engineer, Shawinigan Water and Power Co., Montreal; K. H. Smith, engineer, Nova Scotia Water Power Commission, Halifax, N.S. Published 1916. Out of print.

Water Resources Paper No. 17.—Canadian Hydraulic Power Development and Electric Power in Canadian Industry, by Charles H. Mitchell, consulting engineer to Dominion Water Power Branch. Part I deals with progress of utilization, features in design, construction and operation specially applicable to Canada. Description of certain typical Canadian water-power developments. Part II analyses the uses, growth and future of electrical power in Canadian industry. Published 1916. Out of print.

Water Resources Paper No. 20.—Report on the Interests Dependent on Winnipeg River Power, with Special Reference to the Capital Invested and the Labour Employed, by H. E. M. Kensit. A detailed study of the industrial growth and future power requirements of the district tributary to the Winnipeg River power sites. Published 1917. Out of print.

Water Resources Paper No. 27.—Directory of Central Electric Stations in Canada to January 1, 1919, compiled by J. T. Johnston, assistant director, Dominion Water Power Branch. Comprises an analysis of the central electric census statistics and a directory of the stations. Published 1919. Out of print.

Water Resources Paper No. 32.—Water Resources Index Inventory, by J. T. Johnston. Description of the Index Inventory System for recording and collating the water resources data of the Dominion. Published 1922. Out of print.

Water Resources Paper No. 33.—Directory of Central Electric Stations in Canada, to November 1, 1922. Comprises an analysis of the central electric station statistics and a directory of the stations. Published 1923. Price, 50 cents.

SURFACE WATER SUPPLY REPORTS

ATLANTIC DRAINAGE SOUTH OF ST. LAWRENCE RIVER, INCLUDING NOVA SCOTIA, NEW BRUNSWICK, PRINCE EDWARD ISLAND, AND SOUTHEASTERN QUEBEC

Water Resources Papers Nos. 29, 37, 45 and 52.—Surface water supply of Canada. Reports on hydrometric surveys covering the Atlantic drainage south of the St. Lawrence river, including Nova Scotia, New Brunswick, and Prince Edward Island and southeastern Quebec, for the climatic years ending September 30, 1919, 1920; 1921, 1922; 1923, 1924; and 1925, 1926, by K. H. Smith, district chief engineer. No. 52, in course of preparation.

ST. LAWRENCE AND SOUTHERN HUDSON BAY DRAINAGE IN QUEBEC

Water Resources Papers Nos. 41 and 48.—Surface water supply of Canada. Reports on hydrometric surveys covering the St. Lawrence and southern Hudson Bay drainage in Quebec, for the climatic year ending September 30, 1923, and climatic years ending September 30, 1924 and 1925, by Leo G. Denis, district chief engineer. No. 48, in course of preparation.

ST. LAWRENCE AND SOUTHERN HUDSON BAY DRAINAGE IN ONTARIO

Water Resources Papers Nos. 28, 34, 38, 42 and 49.—Surface water supply of Canada. Reports on hydrometric surveys covering the St. Lawrence and southern Hudson Bay drainage in Ontario, for the climatic years ending September 30, 1920, 1921, 1922, 1923, and 1924-25, by S. S. Scovil, district chief engineer. No. 49, in course of preparation.

ARCTIC AND WESTERN HUDSON BAY DRAINAGE (AND MISSISSIPPI DRAINAGE IN CANADA) IN ALBERTA, SASKATCHEWAN, MANITOBA, EXTREME WESTERN ONTARIO, AND NORTHWEST TERRITORIES

Water Resources Papers Nos. 4, 19, 22, 24 and 26.—Surface water supply of Canada. Reports on hydrometric surveys in Manitoba, from January 1, 1912, to September 30, 1919, by M. C. Hendry and C. H. Attwood, chief engineers. No. 4 contains a gazetteer of lakes and streams in Manitoba.

CLASSIFIED LIST OF PUBLICATIONS—Concluded

Water Supply Bulletins Nos. 1 to 11.—Surface water supply of Canada. Reports on hydrometric surveys in Alberta and Saskatchewan from 1908 to September 30, 1919, by P. M. Sauder and A. L. Ford, chief hydrometric engineers, Reclamation Service.

Water Resources Papers Nos. 31, 36, 40, 44, 46 and 50.—Surface water supply of Canada. Reports on hydrometric surveys covering the Arctic and western Hudson Bay drainage (and Mississippi drainage in Canada) in Alberta, Saskatchewan, Manitoba, extreme western Ontario and the Northwest Territories, for the climatic years ending September 30, 1920, 1921, 1922, 1923, 1924 and 1925, by C. H. Attwood and A. L. Ford, district engineers. Previous to 1919-1920 the surveys in Alberta and Saskatchewan were carried on and the results published by the Reclamation Service, Department of the Interior. No. 50, in course of preparation.

PACIFIC DRAINAGE IN BRITISH COLUMBIA AND THE YUKON TERRITORY

Water Resources Papers Nos. 1, 8, 14, 18, 21, 23, 25, 30, 35, 39, 43, 47 and 51.—Surface water supply of Canada. Reports on hydrometric surveys covering the Pacific drainage in British Columbia and the Yukon Territory from May, 1911, to September 30, 1925. No. 1 is by P. A. Carson, chief engineer, the others by R. G. Swan, district chief engineer. No. 1 contains an outline of the history of the Railway Belt with special reference to its administrative, legal and physical problems in regard to water, and a gazetteer of the lakes and streams in British Columbia. No. 51, in course of preparation.

MAP

Water Powers of the Dominion of Canada, prepared in connection with the First World Power Conference, London, Eng., 1924.

RECLAMATION

Drainage Regulations.

Irrigation Regulations.

Annual Irrigation Reports.—1894 to 1911. Out of print.

Annual Irrigation Reports.—Calendar years 1912 to 1915.

Irrigation Surveys and Inspections Reports—Fiscal years 1915-16, 1916-17, 1917-18, 1918-19.

Annual Report of the Reclamation Service.—1919-20, 1920-21, 1921-22, 1922-23.

Annual Report of the Dominion Water Power and Reclamation Service.—1923-24, 1924-25.

Western Canada Irrigation Association Reports.—1st to 11th Convention, 1907 to 1917.

International Irrigation Congress Report 1914.

Bulletin No. 1.—Irrigation in Alberta and Saskatchewan. (Consisting of a Synopsis of the Irrigation Act and its Administration.)

Bulletin No. 2.—Alfalfa Culture.

Bulletin No. 3.—Climatic and Soil Conditions, C.P.R. Irrigation Block.

Bulletin No. 4.—Duty of Water Experiments and Farm Demonstration Work.

Bulletin No. 5.—Farm Water Supply.

Bulletin No. 6.—Irrigation Practice and Water Requirements for Crops in Alberta.

Pamphlets:

Address by Mr. S. G. Porter—"Practical Operation of Irrigation Works."—Extract from W.C.I.A. Report, 1914.

Address by Dr. Rutherford—"Inter-dependence of Farm and City."—Extract from W.C.I.A. Report, 1914.

Address by Mr. Don. H. Bark—"The Actual Problem that Confronts the Irrigator."—Extract from W.C.I.A. Report, 1914.

Address by Mr. Don. H. Bark—"Practical Irrigation Hints for Alberta."—Extract from W.C.I.A. Report, 1915.

Address by Mr. Don. H. Bark—"Alfalfa Growing."—Extract from W.C.I.A. Report, 1915.

"Practical Information for Beginners in Irrigation" (by W. H. Snelson, A.M.E.I.C.).

Water Resources Papers, and Irrigation and Drainage Reports, as listed at the end of this report are issued gratis, with the exception of Water Resources Paper No. 33, for which a charge of 50 cents is made. These can be had on application to the Director of Dominion Water Power and Reclamation Service, Department of the Interior, Ottawa.

DEPARTMENT OF THE INTERIOR, CANADA

HON. CHARLES STEWART, Minister; W. W. CORY, C.M.G., Deputy Minister

DOMINION WATER POWER AND RECLAMATION SERVICE

J. T. JOHNSTON, C.E., Director

ANNUAL REPORT

1925-26

OTTAWA
F. A. ACLAND
PRINTER TO THE KING'S MOST EXCELLENT MAJESTY
1927

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AND

RECLAMATION SERVICE

FOR THE

Fiscal Year Ending March 31, 1926

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WATER POWER AND RECLAMATION

INTRODUCTORY

On April 1, 1925, Mr. J. B. Challies, Director of the Dominion Water Power Branch and the Reclamation Service, resigned to take up a position with a large private corporation and his place was filled by the promotion of Mr. J. T. Johnston, C.E., the vacancy of assistant director being filled in turn by the promotion of Mr. S. S. Scovil, B.Sc., supervising hydrometric engineer.

ORGANIZATION

International Waterway Matters.—The organization of the Dominion Water Power and Reclamation Service in field and office is such as to facilitate the ready compilation and analysis of run-off and other hydrometric and hydraulic data on boundary waters and on waters flowing into boundary waters along the international boundary between Canada and the United States. Because of these facilities the service has been charged with the responsibility of securing such data and of making such studies as are necessary for an intelligent consideration of all matters affecting boundary waters, and of advising the minister with respect thereto.

Water-power.—The water-power activities are both administrative and investigatory. The proprietary interest of the Dominion in the water resources of Alberta. Saskatchewan and Manitoba, of the Northwest and Yukon Territories and of the Railway Belt in British Columbia gives rise to the necessity of administering these resources in accordance with the Dominion Water Power Act and the Regulations thereunder, and places upon this service the responsibility of securing such fundamental engineering and economic data as will enable it properly to control the development, distribution and sale of hydro-electric energy.

Throughout the rest of Canada the water-powers are vested in the provinces and investigatory work is carried on in co-operation with the respective provincial authorities charged with the administration of these resources. The service also co-operates extensively with federal departments and commissions other than the Department of the Interior, making the services of its field engineering staff available to these organizations when, in the interests of general economy and efficiency, it is desirable to do so.

The co-operative water-power and hydrometric survey work is undertaken through district offices, each in charge of a district chief engineer, located as follows: British Columbia, at 739 Hastings street west, Vancouver; Alberta and Saskatchewan, at Southam chambers, Calgary; Manitoba, at 231 Chambers of Commerce block, Winnipeg; Ontario, the local organization has headquarters at the Ottawa office of the service; Quebec, at 201 Inspector street, Montreal; the Maritime Provinces, at 193 Hollis street, Halifax. In every case the district offices are operated in the closest co-operation with the provincial officers engaged in the administration or use of water or water-power.

In the Yukon and Northwest Territories the water-power resources are administered from Ottawa, and, in the case of the Yukon, through the Gold Commissioner at Dawson. Investigatory work in the Yukon is handled through the British Columbia organization and in the remainder of the territories as the exigencies of the situation demand.

The water-power field organization is based upon and built up around the Dominion Hydrometric Survey staff, through which systematic and continuous stream measurement studies are carried on throughout the Dominion. The data secured by the hydrometric staff and through the co-operative efforts of the various provincial and other organizations are collated, analysed and standardized at the head office of the service at Ottawa, with the result that there is already available in Ottawa both general and detailed information concerning the run-off and power possibilities of the more important power rivers throughout Canada. These data are constantly being revised as new or later information is received and are promptly available for reference to all interested in the utilization of the water-powers of the Dominion.

Irrigation and Drainage.—The Federal Irrigation Act and the Federal Reclamation Act, together with the Regulations thereunder, provide the bases of irrigation and drainage activities.

Under the provisions of the Irrigation Act the ownership and administration of all surface water supply in the provinces of Alberta, Saskatchewan, and northern Manitoba are vested in the Crown. All licenses for the use of water are conditional upon continuous beneficial use. A local organization, in charge of the Commissioner of Irrigation, Calgary, is responsible for the field administration.

The Reclamation Act and the Regulations are administered along similar lines. All field investigations are carried out by the local office upon instructions from Ottawa. Any questions of drainage affecting departmental interests in the provinces of Manitoba and British Columbia are dealt with through the agency of the district chief engineers of this service in those provinces. Close co-operation is maintained with the provincial drainage departments at all times.

PUBLICATIONS

A list of the Annual Reports, Water Resources Papers and Reclamation Reports published to date will be found at the end of this report, and copies of those which are still in print will be sent on application to those interested, free of charge, except in the case of the Directory of Central Electric Stations in Canada, for which a charge of fifty cents is made.

During the past year Water Resources Papers Nos. 41, 44, 45, and 47 were published. The Annual Report for the fiscal year 1924-25 and Water Resources Paper No. 46 are now in press. Bulletins were issued dealing with Hydro-Electric Progress in Canada during 1925 and the Water-Power Resources of Canada as at January 1, 1926.

PART I

HEAD OFFICE

INTERNATIONAL WATERWAY MATTERS

During the year international waterway problems continued to receive close consideration and detailed studies of the various phases entering therein were intensified. The more important problems to which attention was directed included those having to do with the Chicago diversion and the Niagara Power situation.

Other active international issues receiving attention included the application of the New Brunswick Electric Power Commission made through this department to the International Joint Commission, for approval of the commission's Grand Falls power project on the St. John river in the province of New Brunswick. This application involved three hearings before the Joint Commission on March 25, 1925, on May 14 and 15, and on June 12, respectively. Approval was given by the commission subject to certain conditions on June 22.

In June the application of the Buffalo and Fort Erie Public Bridge Company for approval to its proposed bridge across the Niagara river connecting Buffalo and Fort Erie was transmitted through this department to the International Joint Commission. A hearing was held at Niagara Falls, Ont., on August 11, 1925, and approval of the commission, subject to certain conditions, was issued on the same date.

Following the execution of the Lake of the Woods Convention between Canada and the United States, on February 24, 1925, there arose, as a part of the agreement entered into, a number of international problems having to do with the provision of remedial and protective works and with compensation for land damages. These are receiving attention and involve considerable international discussion and co-operation.

Incorporated in the Lake of the Woods Convention is the new Rainy Lake Reference to the International Joint Commission, which has to do with the provision of storage in Rainy lake and in the boundary waters above, and with the development of power in connection therewith.

On September 28 to 30 the first hearing of the International Joint Commission on this reference was held at Fort Frances, Ont., at which various representations for and against the power and storage projects were presented. Extensive field investigations have been made by this service looking to the securing of data for the proper analysis of the problems involved. Further detailed field studies are required and are under way in this connection.

In accordance with the rulings of the International Joint Commission made on October 4, 1921, in conformity with the Boundary Waters Treaty of 1909, the measurement and apportionment of the stream flow in the St. Mary and Milk rivers and their tributaries in the provinces of Alberta and Saskatchewan and in the state of Montana were continued during the past year by an engineer of this service in co-operation with an engineer of the United States Reclamation Service. The report covering the year's operation is now in course of preparation for presentation to the commission upon the occasion of its regular semi-annual meeting in April.

Other international waterway issues have been raised in connection with the Kootenay Flats reclamation project, the pollution of international waters

at various points along the boundary, the Red River drainage matter, the international tidal power project of Dexter P. Cooper in Passamaquoddy bay and others.

During the year the international responsibilities of the service were materially increased by the appointment of the Director of Water Power and Reclamation as Canadian representative on various International Waterway control boards in succession to the late W. J. Stewart. The responsibilities arising as a result of this representation were dealt with as they arose from time to time throughout the year. One of the more important matters had to do with the apportionment of water at Niagara for power purposes as between Canada and the United States under Article V of the Boundary Waters Treaty of 1909. On June 15 the Niagara Board of Control, after an exhaustive study of the water used by the various power plants on both sides of the river, issued a report to the effect that the amounts of water authorized for diversion for power purposes by the Boundary Waters Treaty were not being exceeded on either side of the border.

WATER-POWER

LAKE OF THE WOODS CONTROL BOARD

The Lake of the Woods Control Board was, as in previous years, responsible for the regulation of the level and outflow of lake of the Woods.

This regulation embraces, among other things, the continuous collection of hydrological data relating to the watershed, and in this connection the board was indebted to the Department of Public Works for run-off records on Rainy and Namakan lakes, and to the Dominion Meteorological Service for precipitation records at numerous stations throughout the watershed. Precipitation throughout the year was about normal but as a consequence of the complete closure of the western outlet of lake of the Woods for construction purposes, lake level rose from elevation 1055.46 on the 1st April, 1925, to elevation 1059.64 on the 31st March, 1926.

The enlargement of the western outlet of lake of the Woods and the reconstruction of the Norman dam was proceeded with during the year, in accordance with the agreement between the Department of the Interior and the Keewatin Power Company. The rock excavation of the western outlet was completed early in October and the reconstruction of the Norman dam was practically completed at the end of March. On the 20th February both the upper and lower cofferdams were removed and the Norman dam was again made the medium of control for lake of the Woods. With the completion of this work, proper and efficient control of levels and outflow in accord with treaty stipulations with the Government of the United States will be possible and protection assured for the domestic water supply and power requirements of Winnipeg, Kenora, and the surrounding districts.

WATER-POWER REGULATIONS AND LEGAL RESEARCH

No new rights have been granted under the Dominion Water Power Regulations during the past year, but some progress has been made in the issue of final licenses to take the place of the original agreements under which two of the large power developments in the Prairie Provinces have been constructed.

The study of Dominion and provincial legislation relating to the uses of water has been continued, more particularly with regard to the effect upon water-power administration. The work in this connection during the past year was confined chiefly to the water-power laws of the province of Quebec. All reported

decisions of the courts of that province bearing upon the subject were consulted and the leading cases analysed for reference.

It is proposed to extend this research to the other provinces, as such information has been found of value in preparing reports and memoranda in response to specific inquiries, of which many are received, or in dealing with administrative questions.

In connection with the administration of international boundary waters, a study has been made of the treaty provisions governing their use for power and other purposes and a large amount of material bearing upon this subject has been examined and collated.

BRITISH COLUMBIA ADMINISTRATION

Water privileges authorizing the use of waters within the Railway Belt or appurtenant to Dominion lands therein which are issued by the province of British Columbia under the provincial Water Act are examined for the due protection of Dominion interests, and the granting of rights in Dominion lands required for the exercise of these privileges, is proceeding satisfactorily, with the close co-operation of the provincial Comptroller of Water Rights.

The arrangement by which the province undertakes the administration of the waters of the Railway Belt, which, together with the ungranted Crown lands therein, belong to the Dominion, has been in force since 1912 under the provisions of the Railway Belt Water Act. This arrangement has, on the whole, given general satisfaction, as it places all water users in the province under the same law and the same local administration. In order to overcome some difficulties which have recently become evident, to quiet any titles to water rights granted by the province as to which future doubts might arise and to prevent the recurrence of such difficulties it is proposed to amend the Railway Belt Water Act.

The examination of water records appurtenant to Indian reserves throughout the province, and the preparation of evidence in support of Indian claims to water rights, has been continued by the local engineering staff of this service and is now almost completed, as, with a few exceptions, all the Indian claims have been adjudicated upon by the Board of Investigation under the Water Act and their rights fully established.

ENGINEERING CO-OPERATION WITH INDIAN DEPARTMENT

At the request of the Department of Indian Affairs, the District Chief Engineer at Winnipeg prepared plans and estimates for a 30-horsepower water-power development to serve the Indian residential school near MacIntosh, Ont., also water supply and sewage disposal systems for that institution, and has supervised the construction of these works, which were carried out during the past year.

Plans and estimates have also been prepared by the same officer for the similar requirements of the Guy Indian school to be built near Sturgeon landing in northeastern Saskatchewan.

A description of the work done in connection with these two schemes will be found in the report of the District Chief Engineer for Manitoba.

The local engineering staff of the service in British Columbia has also conducted a number of investigations on behalf of the Department of Indian Affairs for the improvement of Indian reserves and to provide increased amenities for the Indians, and a considerable amount of construction has been carried out under the supervision of these local officers. These matters are discussed more fully in the report of the District Chief Engineer for British Columbia.

WATER RESOURCES INDEX INVENTORY

The water resources index inventory system for the recording and collating all water resources data for the Dominion was devised some years ago by the service and has since been found most advantageous in its application. A detailed description of the system has appeared in the annual report for 1916-17 and in the combined reports for the years 1917-18-19.

The index inventory has been found of particular utility in its application to the complete census of developed water-power, and in the analysis of central electric station activities, undeveloped water-power resources, stream measurement activities and storage investigations.

The data compiled are being continually revised in accordance with the most up-to-date information and as a result of a number of years of such effort a very large amount of information in standardized form is now available. The work has been facilitated by the co-operation of many provincial organizations such as the Hydro-Electric Power Commission of Ontario, the Quebec Streams Commission, the British Columbia Water Rights Branch, the Nova Scotia Power Commission, and the New Brunswick Electric Power Commission.

WATER-POWER RESOURCES OF CANADA

The ever growing application of electricity to industry, the increasing public demand for better street, domestic and commercial lighting and the widespread use of electricity for domestic and commercial cooking, refrigerating and the numerous other purposes made possible by reasonably priced electrical appliances have all united to create a demand for power which is being met by an unprecedently rapid development of Canada's water-power resources.

The fortunate occurrence of about 60 per cent of Canada's total water-power in the highly industrial, but non-coal producing provinces of Ontario and Quebec, the close proximity of water-powers to the mineral and pulp wood areas throughout the entire country and the fact that nearly all of our centres of population have water-power within easy transmission distance are circumstances which, while of course altogether fortuitous, combine to provide a market for power in which the supply barely keeps pace with the demand. Indeed this is one of the outstanding points of interest in present day developments. Where a few years ago blocks of 10 to 20,000 h.-p. would come on the market after an extended period of construction now plants of 100,000 h.-p. or more are brought into operation within the year.

The year 1925 witnessed the unprecedented increase in Canada's hydraulic installation of 718,984 h.-p. bringing the total installation for all purposes to the imposing total of 4,290,428 h.-p. or 465 h.-p. per 1,000 of population. While actual construction during 1925 was confined to only four of the provinces, British Columbia, Manitoba, Ontario, and Quebec, considerable activity preliminary to construction was evidenced in other provinces. While it is hardly to be expected that 1926 will witness activity equal to that of the past year there is sufficient construction under way or in prospect to maintain the high average of recent years. That the limit of individual plant capacity has not been reached even by the great stations recently constructed is indicated by the inception of a plant on the Saguenay river of 800,000 h.-p. ultimate capacity while plans for an enterprise of almost equal ultimate capacity on the Bridge river in British Columbia involving the development of a series of sites are in course of preparation.

While complete information regarding Canada's great water-power resources is not yet available, all existing stream-flow and power data from federal, provin-

cial and private sources have been systematically collated, analysed and co-ordinated with the object of presenting a dependable estimate of available power based on uniform methods of computation and arrangement.

BASIS OF COMPUTATION

The figures for available water-power listed in table 1 are based upon rapids, falls and power sites of which the actual existent drop or the head possible of concentration, is definitely established or at least well authenticated. Many rapids and falls of greater or lesser power capacity are scattered on rivers and streams from coast to coast which are not as yet recorded, and which will only become available for tabulation as more detailed survey work is undertaken and completed. This is particularly true in the relatively unexplored northern districts. Nor is any consideration given to the power concentrations which are feasible on rivers and streams of gradual gradient, where economic heads may be created by the construction of power dams, excepting only at such points as definite studies have been carried out and the results made matters of record.

In brief, the figures hereunder are based on definite rapids, falls and power sites, and may be said to represent the *minimum water-power possibilities of the Dominion.*

The power estimates have been calculated on the basis of 24-hour power at 80 per cent efficiency for conditions of "Ordinary Minimum Flow" and "Ordinary Six Months Flow". The "Ordinary Minimum Flow" is based on the averages of the flows for the two lowest periods of seven consecutive days in each year, over the period for which records are available. The "Ordinary Six Months Flow" is based upon the continuous power indicated by the flow of the stream for six months in the year. The actual method to determine this flow is to arrange the months of each year according to the day of the lowest flow in each. The lowest of the six high months is taken as the basic month. The average flow of the lowest seven consecutive days in this month determines the ordinary six-month flow for that year. The average of such figures for all years in the period for which data are available is the ordinary six-month flow used in the calculation.

Estimate of power on the basis of ordinary six-month flow are made upon the assumption that it is good commercial practice to develop wheel installation up to an amount, the continued operation of which can be assured during six months of the year, with the deficiency in power during the remainder of the year provided from storage not yet created or by the installation of fuel power plants as auxiliaries. The correctness or otherwise of this assumption for any particular site can only be definitely settled by careful consideration of all circumstances and conditions pertinent to its development. The method, however, enables a fairly satisfactory overall estimate of the maximum hydraulic power available, to be made as distinctive from the estimated ordinary minimum power available.

AVAILABLE AND DEVELOPED TOTALS

The known available water-power in Canada from all sources and within the limitations outlined, is 18,255,000 h.-p. for conditions of ordinary minimum flow and 32,076,000 h.-p. ordinarily available for six months of the year.

It is believed that these are conservative estimates since an analysis of the water-power plants scattered from coast to coast concerning which complete data are available as to turbine installation and satisfactory information as to stream-flow, gives an average machine installation 30 per cent greater than the ordinary six-month-flow power. Applying this, the figures quoted above, therefore, indicate that the present *recorded water-power resources* of the Dominion will permit of a turbine installation of 41,700,000 h.-p.

The total installation to date in water-wheels and turbines throughout the Dominion is 4,290,428 h.-p. In other words the present turbine installation represents only *10¼ per cent* of that possible with the recorded water-power resources.

CURRENT PROGRESS IN DEVELOPMENT

Hydro-Electric and water-power development in Canada reached record proportions during the year 1925, the increase in the total installation far exceeding that of any previous year. This is indicated by the review of the year's activities prepared by this service whose records show that 719,000 h.-p. was added during the year, bringing the total installation in the Dominion to 4,290,000 h.-p. Many projects are also under way which will add more than 250,000 h.-p. in the early part of 1926.

Not only was 1925 of outstanding interest on account of the large increase in installed capacity, but it marked the bringing into operation or completion of a number of large projects which have been under active construction for the past few years. Of these the most notable are the Queenston development of the Ontario Hydro-Electric Power Commission on the Niagara river with 500,000 h.-p. completely installed, and the development of the Duke-Price Power Company on the Saguenay river in Quebec which brought into operation 360,000 h.-p. of an ultimate capacity of 540,000 h.-p. While the next year or two are not expected to witness as large increases as 1925 there are projects of great magnitude now under way or in early prospect which will provide substantial additions as they are brought into operation. These include the 800,000-hp. development recently commenced at Chute a Caron on the Saguenay river by the Aluminum Corporation of Canada, and a project of almost the same ultimate proportions on the Bridge river in British Columbia by the British Columbia Electric Railway Company. Numerous other developments of lesser capacity have either been commenced or are in early prospect, so that there is every assurance that the average growth of the past few years will be well maintained in the future.

The widespread nature of the 1925 activities is disclosed in the following paragraphs which outline the developments by provinces. Quebec led with a total installation of 438,300 h.-p., largely contributed by the development of the Duke-Price Power Company; Ontario, followed with almost 200,000 h.-p., contributed chiefly by the Queenston development of the Ontario Hydro-Electric Power Commission. Other provinces having important additions were British Columbia with 58,984 h.-p. and Manitoba with 21,900 h.-p.

British Columbia.—The 58,984-hp. net addition to British Columbia's total during 1925 was contributed by two developments, the Stave Falls plant of the British Columbia Electric Railway Company and the Lower Bonnington Falls plant of the West Kootenay Light and Power Company.

At Stave falls on the Stave river the British Columbia Electric Railway Company brought to completion work begun in 1922 which involved the trebling of the storage capacity in Stave lake both by the raising of the lake level 22 feet by new dam construction and by diverting the waters of Alouette lake to Stave lake by the construction of a tunnel. Due to the increase in head and the additional water supply a fifth unit of 15,000 h.-p. was added during 1925 to the plant and the other four units raised to the same capacity, necessitating the rewinding of the existing generators. The net increase in capacity amounted to 23,000 h.-p.

Good progress was made by the same company in the work under way at Alouette lake. The dam at the outlet of the lake and the tunnel 3,550 feet long leading the waters to Stave lake were completed during the year. It is expected that the power station at the Stave lake end of the tunnel, with an installation of 12,500 h.-p. will be completed during 1926.

At Lower Bonnington falls on the Kootenay river the West Kootenay Light and Power Company replaced its old plant of 4,016 h.-p. with an entirely new development. Two units of 20,000 h.-p. each were brought into operation on July 1, 1925, and a third unit of similar capacity will be added during 1926. The company is also rewinding two of the generators in its Upper Bonnington Falls plant to secure increased power capacity.

The Powell River Company completed the raising of its storage dam on Powell river during the early part of the year and work is in progress on the construction of a 14-foot diameter penstock which will supply three new units of a total capacity of 25,860 h.-p. These units it is anticipated will be in operation early in 1926.

Of developments in prospect the most important is that of the British Columbia Electric Railway Company on Bridge river. The company during the year exercised its option for the purchase of all the shares of the Bridge River Power Company and has drawn up a program of development starting probably in 1927. It is expected that the development will be accomplished in successive stages commencing with an initial installation of 54,000 h.-p. and reaching ultimately a total of from 550,000 to 700,000 h.-p.

Manitoba.—The increase of 21,900 h.-p. in Manitoba's total during 1925 was entirely in the Pointe-du-Bois plant of the city of Winnipeg on the Winnipeg river. Three units of 7,300 h.-p. were added during the year and contracts were awarded for two further units of the same capacity for delivery in 1926. These last units will bring the Pointe-du-Bois plant to its full capacity of approximately 104,000 h.-p.

The Manitoba Power Company has entered into a contract to supply power to the Manitoba Pulp and Paper Company's mill now being built at Fort Alexander, at the mouth of the Winnipeg river. The Manitoba Power Company has a development of 56,000 h.-p., present capacity, at Great Falls on the Winnipeg river and, it is reported, will immediately enlarge this by the addition of a third unit of 28,000 h.-p. and later by a fourth unit of the same capacity.

The Manitoba Power Commission, which purchases hydro-power and distributes it in the southern part of the province, has been active during the year in extending its lines. These extensions include lines from Jordan west to Miami, from Carman east to Sperling and from Roland east to Myrtle, amounting in all to 35 miles.

Ontario.—The total increase in the Ontario installation was 199,750 h.-p. during 1925. While this was chiefly accounted for by developments of the Ontario Hydro-Electric Power Commission, there were other developments by private organizations of notable importance.

The Ontario Hydro-Electric Power Commission added two units of 55,000 h.-p. each to its Queenston plant on the Niagara river, thus bringing this, the largest completed development in the Dominion, to a capacity of nine units and 500,000 h.-p. with the possibility of the addition, later, of a tenth unit. In the western part of the province the commission added two units of 12,500 h.-p. to its Cameron Falls plant on the Nipigon river, thus bringing this development to its full capacity of 75,000 h.-p. For the benefit of the same plant a dam at Virgin falls was completed which will provide for complete regulation of the discharge from lake Nipigon.

In the Georgian Bay system the commission completed the reconstruction of the South Falls plant on the South Muskoka river, increasing its capacity by 3,750 h.-p. A short distance above South falls a new plant of 1,800-hp. capacity is being constructed at Hanna chute. This is expected to be ready for operation about March, 1926. For the further supply of this territory detailed field investigations were made of the power possibilities on the Musquash or Lower Muskoka river.

For the supply of the Central Ontario system a new development of 4,800-hp. capacity was completed during the month of May at Dam 9 on the Trent canal below Campbellford, this plant being operated by remote control from the Ranney Falls station a few miles distant.

The commission also continued its investigations of further sources of power on other rivers of the province, notably the possibilities on the Ottawa and St. Lawrence rivers.

Among the activities of private organizations, the Abitibi Power and Paper Company acquired the 24,000-hp. development at Island falls on the Abitibi river from the Hollinger Consolidated Gold Mines and added 24,000 h.-p. to its capacity during the year, the power being transmitted to the company's mills at Iroquois Falls. The same company added a 6,000-hp. unit to its development at Twin Falls on the Upper Abitibi river.

In the extreme westerly part of the province, the Keewatin Power Company substantially completed the construction of a 17,000-hp. development at the western outlet of the lake of the Woods, at the same time improving the discharge capacity of the western outlet and reconstructing the Norman dam. The power thus provided will be used by the pulp and paper mills at Kenora.

In the Sudbury district the Wahnapitae Power Company completed a new development of 7,000 h.-p. on the Wanapitei river. On Manitoulin island a new plant of 1,750-hp. capacity was built on the Kagawong river for the Manitoulin Pulp Company.

Two developments are under construction by the Quinte and Trent Valley Power Company which it is expected will be completed early in 1926. The first is at Campbellford, on the Trent river, where 1,100 h.-p. is being installed, and the second at Frankford on the same river with an installation of 2,980 h.-p.

Quebec.—As has already been stated 1925 was a record year in water-power development in Quebec province with new installations totalling to 439,000 h.-p. This increase was largely accounted for by the bringing into operation of the Isle Maligne development of the Duke-Price Power Company on the Saguenay river with an initial installation of 360,000 h.-p. Work is proceeding on the extension of the plant which it is expected will raise the total to 480,000 h.-p. by February, 1926. The energy from this development is to be supplied to various pulp and paper mills of the district and temporarily to the proposed reduction plant of the Aluminum Corporation of Canada.

In the Eastern Townships the Southern Canada Power Company completed the installation of a 37,800-hp. plant at Hemming falls on the St. Francois river, while the 12,000-hp. extension of the company's Drummondville plant on the same river is expected to be ready before the close of the year. Both these developments supply the company's extensive transmission system located in this industrial portion of the province, additional lines having also been completed during the year.

In the southwestern part of the province the Ottawa River Power Company brought into operation its plant at Bryson, on the Ottawa river, with an initial installation of 25,000 h.-p., the ultimate designed capacity being 75,000 h.-p. The energy is transmitted to Ottawa, Hull and district.

The Chicoutimi Electric Company's 3,500-hp. plant at Garneau fall on the Chicoutimi river was also placed in operation during the past summer.

Two other hydro-electric undertakings are well advanced and are expected to be placed in operation in the near future. The largest of these is the Shawinigan Water and Power Company plant on the Batiscan river at St. Narcisse, which will probably be completed by July, 1926. The plant is to have an initial installation of 22,800 h.-p. and an ultimate capacity of 45,600 h.-p. in units of 11,400 h.-p. each and will be used to supply additional energy to the company's system.

North of Ottawa, the Gatineau River Power Company expects to complete the extension of its plant on the Gatineau river near Maniwaki by February,

1926. The plant will have an installation of 2,500 h.-p. with provision for an ultimate 3,750 h.-p. to supply a transmission system extending to Gracefield.

Of construction recently started, the largest power project of the province has been commenced at Chute a Caron on the Saguenay river. This has been undertaken by the Aluminum Corporation of Canada to supply its new reduction works and an installation of some 800,000 h.-p. has been proposed in this connection.

An important project for the International Paper Company on which construction has also just started is to include a power development of considerable magnitude at Chelsea, on the Gatineau river, and a pulp and paper mill a few miles distant near East Templeton.

Other developments and extensions on which preliminary construction was started during the year include the 2,500-hp. Canada Paper Company's plant at Ulverton rapid on the St. Francois river; the improvements to the Montreal Cotton Company's plant at Valleyfield to secure an output of 12,000 h.-p. the company also having in view a 5,000-hp. extension later on; the preliminary work started by the Shawinigan Water and Power Company in connection with rebuilding a hydro-electric plant on the Ste. Anne-de-la-Perade river at St. Alban, the probable installation to be 4,000 h.-p.

Among the more or less definite projects being considered by various organizations may be mentioned a water-power development by the Ontario Paper Company for pulp mill operation on the Manicouagan river, on the north shore of the St. Lawrence opposite Metis, the whole or partial development of Chats falls on the Ottawa river by the Kingdon Mining Company; a development on the Coaticook river by the town of Coaticook; a possible 1,000-hp. development on du Loup river by the Kamouraska Hydro-Electric Limited; a contemplated development of moderate size on Chiens river near Quebec by the Montmorency Power Company, involving a head of some 800 feet, one of the highest in Eastern Canada.

The excellent work of the Quebec Streams Commission has continued to greatly benefit and encourage the development of water-power in the province. In addition to the operation of extensive storage reservoirs on the St. Maurice, St. Francois and Ste. Anne-de-Beaupre rivers, the commission completed and brought into operation two additional reservoirs of importance and pursued extensive surveys and studies of fourther storage projects and power sites. The Kenogami Lake reservoir controlled by the Taschereau dam was completed and the full storage of thirteen billion cubic feet is being utilized to regulate the Sables and Chicoutimi rivers. The Metis reservoir of two and three-quarter billion cubic feet capacity was also completed and is being operated to regulate the flow of the river of the same name. Storage reservoir surveys and studies by the commission include lakes Baskatong and Kabonga on the upper Gatineau, a detail survey of Mekinac Lake project on the St. Maurice, surveys of Tremblant lake on a lower tributary of Rouge river and of Morin lake on Fourchue river, an upper tributary of du Loup river, Temiscouata county. The commission also carried out a survey of possible power sites in the Upper Ottawa basin up to lake Victoria and has under study a proposed dam and flood prevention works on Bras river, a tributary of Gouffre river at Baie St. Paul.

Maritime Provinces.—With the exception of a small installation of 245 h.-p. in the Annapolis plant in Nova Scotia no actual hydro-electric construction was carried out in the Maritime Provinces during 1925. A number of projects are, however, in active prospect. In New Brunswick the matter of the best policy to adopt in connection with the development of Grand falls on the St. John river is occupying the attention of the provincial Government. International difficulties in the way of developing this site were adjusted at a hearing held by the International Joint Commission early in the year.

On the Nipisiguit river the Bathurst Company has plans under way for a storage dam on Nipisiguit lakes to increase the dependable water supply at the company's plant at Great Falls.

In Nova Scotia the Nova Scotia Power Commission proposes to construct a storage dam at the foot of Lochaber Stillwater on East River Sheet Harbour, in order to meet the request of the Albany Perforated Wrapping Paper Company for additional power. It is also proposed to increase the capacity of the commission's St. Margaret Bay plant by diverting the run-off from 12 square miles of drainage from the head waters of the Sackville river.

The Scott Tissue Company is endeavouring to locate a suitable site in Nova Scotia for a small pulp and paper mill requiring an initial installation of 1,750 h.-p. with a further 1,000 h.-p. later.

The Cochrane Hill Gold Mines have applied for permission under the Nova Scotia Water Act, to develop from 100 to 200 h.-p. on McKeen's brook for gold mining purposes.

Plans are in course of preparation for a pulp and paper enterprise on the Mersey river at Liverpool, N.S., based upon the very considerable water-power and timber resources available. United States interests are also seeking about 4,000 h.-p. on the Liscomb river for pulp grinding.

A rural distribution system some 20 miles in length is in course of construction to supply the small communities of Brooklyn, Newport, Newport Station, St. Croix and Ellershouse for which energy will be secured from the Avon River Power Company.

UTILIZATION OF DEVELOPED WATER-POWER

A study of the uses to which the water-power installation of Canada is put emphasizes the growing importance of central electric stations. The 4,290,428 h.-p. at present installed throughout the Dominion is apportioned to the following uses (see table 2): 3,466,422 h.-p. or 80·8 per cent of the total in central electric stations for general distribution, for domestic, municipal and commercial lighting and power purposes; 481,971 h.-p. or 11.2 per cent installed in pulp and paper mills. In addition pulp and paper mills purchase about 275,000 h.-p. from central electric stations, making a total of nearly 757,000 h.-p. used in the manufacture of pulp and paper.

Three hundred and forty-two thousand and thirty-five h.-p., or 8·0 per cent, installed in industries other than central electric stations and pulp and paper mills.

The total installation for the Dominion averages 465 h.-p. per 1,000 of population, a figure which places Canada among the leading countries of the world in per capita utilization of water-power.

WATER-POWER IN THE CENTRAL ELECTRIC STATION INDUSTRY

As indicated by the foregoing classification the development of electricity for public distribution constitutes the leading use to which water-power development is put and there is every indication that the proportion used for this purpose will continue to increase. In the year 1900, when electricity was just beginning to come into common use, some 32 per cent of Canada's hydraulic installation was in central electric stations. Ten years later the percentage had almost doubled (61 per cent), while by 1920 over 71 per cent was devoted to this purpose, growing, as shown, to 80·8 per cent in the next four-year period. A number of factors contribute to this continued growth, notably the extensive economic radius of modern electrical transmission combined with the fortunate location of water-powers in relation to centres of population and industry without adequate local fuel supplies. The special adaptation of hydraulic power to

central electrical station operations is emphasized by the fact that the last completed central electric station census, that for the year 1924, shows that 95·0 per cent of the total main plant equipment is in hydraulic generating stations and that this equipment produces 98·4 per cent of the total electrical output.

At the present time there are 297 hydro-electric central stations in Canada with a total installation of 3,466,422 h.-p. Of these totals, 209 stations with an installation of 513 turbines of a combined capacity of 2,230,848 h.-p. are owned by commercial organizations, while municipal or other public organizations operate 88 stations which contain 213 turbines aggregating 1,235,574 h.-p. (table 3). The average installation of the commercial stations is 10,674 h.-p., and the average capacity of their turbines 4,193 h.-p., as compared with 14,041 h.-p. and 5,801 h.-p. respectively for the municipal stations. Although as shown by table 2 Ontario has the largest central station installation among the provinces, the commercial group in Quebec forms the largest group, with 1,380,632 h.-p., Ontario's municipal stations being next in order with 1,078,-041 h.-p.

Individual turbines vary in size from 10-hp. turbines used for hamlet lighting to the 55,000-hp. units of the great Chippawa-Queenton station while contracts for units of 80,000 h.-p. for installation in the Saguenay River plant of the Aluminum Corporation of Canada are soon to be let.

WATER-POWER IN THE PULP AND PAPER INDUSTRY

A recent development that is doing much to enhance the importance of the Canadian pulp and paper industry is the growing movement of United States mills towards Canada, due to the diminishment of their pulpwood limits, and the fact that their water-powers have, with the growth of population, attained more value for central station purposes than for pulp and paper manufacturing.

The fortunate occurrence of large supplies of pulpwood in close proximity to water-powers, readily developable and of such size as to furnish the large quantities of power demanded, have placed Canada in the favourable position she occupies in this industry. Owing to large power demand—approximately 100 h.-p. per ton of daily output of newsprint—and the cost of transporting a bulky product such as pulpwood any great distance, this proximity of wood and power is absolutely essential to successful operation.

A recent development of interest affecting the power consumption of this industry is the rapid adoption of elecrtic steam boilers as a means of transforming any surplus of available electric energy into steam for pulp cooking, drying, heating, etc. Ordinarily steam cannot be produced by electricity in direct competition with coal but where surplus power can be contracted for at a specially low rate, or, where large consumers buying firm power, have, periodically, an available surplus in excess of actual power requirements, such surplus power can be advantageously used in raising steam. Similarly, mills maintaining their own hydro-electric equipment are able to make full use of the water at their disposal by utilizing for raising steam any excess of supply over actual power requirements.

There are 116 pulp and paper mills in Canada operating water-power developments to furnish their own motive power. These mills have a combined installation of 481,971 h.-p. A number of these mills purchase additional power from central station organizations while still other mills purchase all their power. Up-to-date figures of this purchased power are not at present available but a conservative estimate places the amount at about 275,000 h.-p., so that the industry draws power from a hydraulic installation of about three-quarters of a million horse-power.

PAST AND FUTURE GROWTH IN UTILIZATION OF WATER-POWER

The modern development of water-power in Canada began with the last decade of the nineteenth century, by the end of which approximately 170,000 h.-p. had been installed. Since then there has been an ever growing rate of progress which brought the total to 4,290,428 h.-p., culminating in the record installation of 1925. With new uses for electricity constantly appearing there is every reason to believe that the past growth will not only be continued but accelerated. Chief among these new uses may be enumerated the electrification of steam railways, the application of electric heat to manufacturing processes, the extension and use of electric boilers for process steam, electric refrigeration and the many other domestic and commercial uses constantly appearing.

CAPITAL INVESTED IN WATER-POWER

The investment represented by our present hydraulic installation of 4,290,428 h.-p. has been made the subject of intensive study based largely on the figures of the annual census of hydro-electric central stations. Due allowance having been made for all the varying factors entering into the development and use of hydraulic power, the statement is warranted that a conservative estimate of the capital investment in Canadian water-powers amounts to $815,723,890.

Table 1.—Available and Developed Water-Power in Canada, January 1, 1926

Province	Available 24-hour power at 80 per cent efficiency		Turbine installation h.-p.
	At Ordinary min. flow h.-p.	At Ordinary 6-months flow h.-p.	
1	2	3	4
British Columbia	1,931,142	5,103,460	414,702
Alberta	475,281	1,137,505	34,107
Saskatchewan	513,481	1,087,756	35
Manitoba	3,270,491	5,769,444	183,925
Ontario	4,950,300	6,808,190	1,784,842
Quebec	6,915,244	11,640,052	1,747,386
New Brunswick	50,406	120,807	44,631
Nova Scotia	20,751	128,264	65,327
Prince Edward Island	3,000	5,270	2,274
Yukon and Northwest Territories	125,220	275,250	13,199
Canada	18,255,316	32,075,998	4,290,428

The figures listed in columns 2 and 3 in the above table represent 24-hour power and are based upon rapids, falls and power sites of which the actual existent drop or the head possible of concentration, is definitely known or at least well established. Many rapids and falls of greater or lesser power capacity are scattered on rivers and streams from coast to coast which are not as yet recorded, and which will only become available for tabulation as more detailed survey work is undertaken and completed. This is particularly true in the less explored northern distrcts. Nor is any consideration given to the power concentrations which are feasible on rivers and streams of gradual gradient, where economic heads may be created by the construction of power dams, excepting only at such points as definite studies have been carried out and the results made matters of record.

The figures in column 4 represent the actual water-wheels installed throughout the Dominion. These figures should not be placed in direct comparison with the available power figures in columns 2 and 3 for the purpose of deducting therefrom the percentage of the available water-power resources developed to date. The actual water-wheel installation throughout the Dominion averages 30 per cent greater than corresponding maximum available power figures calculated as in column 3. The figures quoted above, therefore, indicate that the *at present recorded water power resources* of the Dominion will permit of a turbine installation of 41,700,000 h.-p. In other words, the present turbine installation represents only *10¼ per cent* of the present recorded water-power resources.

The above figures may be said to represent the *minimum water-power possibilities* of the Dominion. As illustrative of this the detailed analyses which have been made of the water-power resources of the provinces of New Brunswick and Nova Scotia have disclosed most advantageous reservoir facilities for regulating stream-flow and it is estimated that the two provinces possess within their respective borders 200,000 and 300,000 commercial h.-p. These figures provide for a diversity factor between installed power and consumers' demands.

Table 2.—Developed Water-Power in Canada, January 1, 1926

Province	Turbine Installation in H.-P.				Population June 1, 1924	Total installation per 1,000 population
	In central electric stations	In pulp and paper mills	In other industries	Total		
1	2	3	4	5	6	7
British Columbia	298,179	54,640	61,883	414,702	553,000	734·0
Alberta	33,520	....	587	34,107	637,000	54·0
Saskatchewan	....	....	35	35	815,000	0·04
Manitoba	167,525	....	16,400	183,925	647,000	284·0
Ontario	1,502,520	174,548	107,774	1,784,842	3,062,000	578·0
Quebec	1,399,607	223,144	124,635	1,747,386	2,480,000	703·0
New Brunswick	23,225	13,003	8,403	44,631	399,400	112·0
Nova Scotia	31,567	16,636	17,124	65,327	533,000	123·0
Prince Edward Island	279	....	1,995	2,274	87,700	26·0
Yukon & Northwest Territory	10,000	....	3,199	13,199	12,040	1,096·0
Canada	3,466,422	481,971	342,035	4,290,428	9,226,740	464

Column 2 includes only hydro-electric stations which develop power for sale.

Column 3 includes only water-power *actually developed* by pulp and paper companies. In addition to this total, pulp and paper companies purchase from the hydro-power central stations totalled in Column 2, horse-power estimated at about 275,000, making a total of about 757,000, *actually used* in the manufacture of pulp and paper.

Column 4 includes only water-power actually developed in connection with industries other than the central station and pulp and paper industries. These industries also purchase blocks of power from the central stations totalled in column 2.

Column 5 totals all turbines and water-wheels installed in Canada.

Column 6 population at June 1, 1924, as estimated by the Dominion Bureau of Statistics.

Column 7 averages the developed water-power per 1,000 population.

Table 3.—Developed Water-Power in Canada Utilized in the Central Electric Station Industry, January 1, 1926

Province	Commercial stations					Municipal stations				
	Number of stations	Number of turbines	Total turbine installation h.-p.	Average h.-p. per station	Average h.-p. per turbine	Number of stations	Number h.-p. turbines	Total turbine installation h.-p.	Average h.p. per station	Average h.-p. per turbine
1	2	3	4	5	6	7	8	9	10	11
British Columbia	20	46	288,084	14,404	6,263	8	11	10,095	1,262	918
Alberta	4	14	32,560	8,140	2,326	1	2	960	960	480
Saskatchewan	....	....	....	....	....	....	....	....	....	....
Manitoba	3	9	78,400	26,133	8,711	2	15	89,125	44,562	5,942
Ontario	74	203	424,479	5,736	2,091	45	132	1,078,041	23,956	8,167
Quebec	86	225	1,380,632	16,054	6,136	16	26	18,975	1,186	730
New Brunswick	5	13	11,315	2,263	870	3	6	11,910	3,970	1,985
Nova Scotia	9	12	5,099	567	425	13	21	26,468	2,036	1,260
Prince Edward Island	7	8	279	40	35	....	....	....	....	....
Yukon and Northwest Territory	1	2	10,000	10,000	5,000	....	....	....	....	....
Canada	209	532	2,230,848	10,674	4,193	88	213	1,235,574	14,041	5,801

Commercial Stations include all privately owned.

Municipal Stations include all publicly owned.

Note.—The statistics in this table are based upon a census of the industry made by the Dominion Bureau of Statistics in co-operation with the Dominion Water Power and Reclamation's Service.

CENSUS OF THE CENTRAL ELECTRIC STATION INDUSTRY

The close interconnection of water-power development and the central electric station industry is evidenced when it is stated that 81 per cent of the total hydraulic installation of Canada is in central electric stations; that 95 per cent of all main plant equipment in central electric stations is driven by water-power and that this equipment generates over 99 per cent of all electricity distributed in Canada.

The ever growing application of electricity to industry and the increasing public demand for those amenities of life made possible by moderately priced power have resulted in 94 per cent of all hydraulic equipment installed during the past five-year period being installed for public distribution through the medium of central electric stations.

The foregoing facts promise the necessity of frequent periodic revision of all basic data relating to the central electric station industry if complete and up-to-date information relative to our water-power resources is to be available, and this revision is made through the medium of the census of the central electric station industry conducted annually by this service in co-operation with the Dominion Bureau of Statistics of the Department of Trade and Commerce. The eighth annual census was completed during the past year and a general statistical analysis showing the status of the industry as at January 1, 1925, published.

DOMINION HYDROMETRIC SURVEY

The Dominion Hydrometric Survey embraces all the provinces of Canada. In the Prairie Provinces the survey is the direct responsibility of the Federal Government and in the other provinces it is carried on under co-operative agreements. Standard methods are used both in field activities and in office administration and water resources information, covering the whole Dominion, is available to the public at one central source. The country is divided in logical divisions of major drainage and these divisions, together with the location of the district office or offices in charge, are as follows: Pacific drainage, Vancouver; Arctic and Western Hudson Bay drainage, Calgary and Winnipeg; St. Lawrence and Southern Hudson Bay drainage, Ottawa and Montreal; Atlantic drainage, Halifax.

The utilization of water resources, particularly in connection with power development and irrigation projects, is continually increasing and there is a pressing demand for detailed and extensive records of the regimen of the numerous lakes and rivers of the country. The importance of stream-flow records is emphasized by the voluntary co-operation, afforded the survey, by numerous individuals and private corporations.

Run-off conditions in Canada.—As shown in detail in the reports of the district chief engineers the average run-off for the year has been normal in British Columbia, above normal in Alberta, Manitoba, and Quebec and below normal in Saskatchewan, Ontario, and the Maritime Provinces.

In the Pacific drainage, stations typical of general run-off conditions indicated a run-off about equal to the long-term mean. In the coast area as typified by Capilano creek a new low run-off was recorded in October.

The run-off from typical stations in the Arctic and Western Hudson Bay drainage ranged from 34 per cent of the normal, on Carrot river, in Manitoba to 139 per cent of the normal of the Clearwater river in central Alberta. For the third time in four years flooding occurred on the Assiniboine river during the break-up period. The flood in March and April last differed from the past two in that the flooding was caused entirely by ice jams in the river. Minimum run-off occurred on the Assiniboine and Swan rivers during the winter. Owing

to the extremely mild weather and light snowfall many of the streams in the western provinces remained open for the greater part of the winter and the major portion of the spring run-off occurred early in March.

In the St. Lawrence and Southern Hudson Bay drainage the run-off of typical stations was generally above the average but no excessive flooding occurred during the year.

In the Atlantic drainage the annual run-off was below normal, except in northern New Brunswick. The outstanding feature of the year, from the standpoint of water supply was the low run-off coincident with melting of the snow and the breaking up of the rivers in the spring.

Power and Storage Investigations.—Power and storage investigations involving field studies, described later on in the detailed reports of the district chief engineers, were only carried out where the demand was urgent or in response to special requests from organizations receiving co-operative assistance from the service. Office studies were, however, vigorously proceeded with in the analysis of the developed and undeveloped water-power resources of the Dominion, the policy of the service being to keep such records continuously up-to-date.

Flooded Land Contours.—During the season of 1925 the work of surveying flood contours along the Winnipeg river was proceeded with in the following townships: 14 in rge. 12, 14 in rge. 13, and 13 and 14 in rge. 14, all east of the Principal meridian.

The shores of the river and adjacent lands were examined and the 905-foot contour was located approximately where necessary between the main diversion dam and Sturgeon falls. In general all sections intersected by the traverse were resurveyed and marked with Dominion Land Survey monuments.

A break was found in the 905-foot contour between traverse stations " 72+6 chains " and " 73+10 chains " in sec. 24, tp. 14, rge. 12. At this point the elevation of the muskeg is 900 feet.

The flood contour was first surveyed around the large island in secs. 1, 2, 11 and 12, tp. 14, rge. 12, E.P.M. This was posted with small wooden posts, no standard survey posts being used.

The contour of the north bank was commenced at traverse hub No. 38 (1921) on the north boundary of sec. 11, tp. 14, rge. 12, E.P.M., and was continued through secs. 11, 12, 13 and 24 in tp. 14, rge. 12, E.P.M., secs. 7, 18, 8, 9, 16 and 15 and along the creek in secs. 23, 24 and 25, tp. 14, rge. 13, E.P.M. In addition the contour was located along both sides of the slough or side channel in secs. 17 and 18, tp. 14, rge. 14, E.P.M.

The contour was not surveyed along the north shore of lake Dorothy, Winnipeg river or lake Jessie between the north boundary of sec. 15, tp. 14, rge. 13 and the east boundary of sec. 7, tp. 14, rge. 14 as the banks along this section are high and generally rocky and no land will be flooded.

The contour in secs. 23, 24 and 25, tp. 14, rge. 13 was for the purpose of reserving the narrow flat through which the creek flows. The flat is from $1\frac{1}{2}$ to $7\frac{1}{2}$ chains wide and a little over one mile long.

The contour of the south bank was commenced at traverse hub No. 91 (1924) on the north boundary of sec. 31, tp. 13, rge. 13, E.P.M. and continued through secs. 6, 5, 4, 9, 10, 15, 14 and 23, and the north half of sec. 13, tp. 14, rge. 13, E.P.M. Between this point and the east boundary of sec. 7 it was not thought necessary to contour the main bank along the west and south shore of lake Jessie. There is, however, an extensive area of low swamp lying to the south of lake Jessie. This is traversed by the Whiteshell and Rennie rivers which unite in sec. 33, tp. 13, rge. 14 and enter lake Jessie in the southeast corner of sec. 7, tp. 14, rge. 14.

The 905-foot contour was located approximately along the east side of the Whiteshell river from the north boundary of sec. 5, tp. 14, rge. 14, through sec. 5, tp. 14, rge. 14 and secs. 32, 33, 4, 3 and 34, to the north boundary of sec. 27 in tp. 13, rge. 14, thence along the west side of the Whiteshell river northward through secs. 34 and 33 and westward along the south side of the Rennie river through secs. 33, 28, 29, 20 and the east half of sec. 19, tp. 13, rge. 14, E.P.M.

On the west side of the Whiteshell river the survey commenced on the north boundary of sec. 5, tp. 14, rge. 14, east and continued through sec. 5, tp. 14, rge. 14, and through secs. 32, 33, 29, 30, 31, tp. 13, rge. 14, E.P.M. The work along the Whiteshell and Rennie rivers has not yet been completed.

Only two settlers were found along the main river in the section surveyed this season. They are homesteaders on secs. 12 and 13, tp. 14, rge. 13 and their land is above flood elevation. One homesteader at the junction of the Whiteshell and Rennie rivers on the NW. $\frac{1}{4}$ sec. 33, tp. 13, rge. 14, owns about 65 acres, the greater part of which is below flood elevation.

The traverse corners were marked by standard Dominion Land Survey posts.

A total of 58 miles of traverse and 74 miles of section lines were surveyed during the season. This required the planting of 483 traverse posts and the construction of 107 standard monuments and 61 temporary wooden posts.

FIELD REPORTS

DISTRICT OF BRITISH COLUMBIA

C. E. Webb, District Chief Engineer

During the fiscal year ended March 31, 1926, regular hydrometric investigatory operations of the Dominion Water Power and Reclamation Service in the province of British Columbia were continued, consistent with the terms of the co-operative agreement between the department and the provincial Government.

ORGANIZATION

Field operations and works are directed from the head office at Vancouver, with a branch office at Kamloops. While the object of the organization is primarily the acquisition and tabulation of stream-flow data for use in the study of power developments, irrigation, reclamation and domestic water supply, the services of engineers of this staff are frequently utilized for other Government departments which are without engineers in British Columbia.

A large amount of work is performed for the Department of Indian Affairs, in connection with the adjustment of Indian Water Rights in British Columbia, as well as the installation of irrigation systems, drainage systems, domestic water supply systems, sewage disposal systems, river bank protection and electric lighting plants on Indian reserves. During the past year two engineering parties have been maintained in the field in addition to an engineer devoting his whole time to the adjustment of Indian Water Rights before the Provincial Board of Adjudication under the British Columbia Water Act.

CO-OPERATION

All hydrometric studies in British Columbia are made by this service under the close co-operative agreement which exists with the provincial Government. Stream-flow data are supplied continuously throughout the year, to the Comp-

troller of Water Rights at Victoria and district water rights engineers throughout the province, and a complete record of all streams is annually supplied to the Water Rights Branch.

Gauging stations have been maintained in co-operation with the Water Resources Branch of the United States Geological Survey on the Columbia, Pend d'Oreille (Clark Fork) and Okanagan rivers, which are all most important international streams.

Extensive hydrometric investigations have been conducted in co-operation with the British Columbia Electric Railway Company in Bridge River district. Seven regular gauging stations have been maintained and miscellaneous records obtained on eleven other streams. All field expenses in this connection are, by arrangement, being paid by the company.

In co-operation with the city of Vancouver, further hydrometric investigations have been carried on to determine the most economical power sites within reasonable transmission distance of the city. All expenses in connection with the maintenance of gauging stations for the city are being borne by the city.

Close co-operation has been maintained with the Greater Vancouver Water District in its investigations for a satisfactory domestic water supply for Greater Vancouver.

As in previous years, close co-operation has been maintained with the Department of Indian Affairs, on all matters requiring engineering assistance or advice. The investigation of Indian Water rights granted prior to March, 1909, has been concluded. All claims to water on behalf of Indians or Indian reserves in the province have been dealt with by the Board of Investigation under the Water Act, and Conditional Water Licenses have been issued in confirmation of claims or in substitution of valid records.

Under Amendments to the 1924 Water Act, passed by the provincial Legislature in December, 1925, all licenses authorizing the diversion of water for use upon Indian reserves were validated and made as secure as possible for the future. Claims to water which for various reasons were recommended to be abandoned, were officially relinquished by the Department of Indian Affairs, which action finally disposed of all outstanding Indian Water Rights in so far as the operations of the Board of Investigation are concerned.

Licenses held by the Department of Indian Affairs for the diversion or storage of water for use upon Indian reserves are as follows:—

Agency	Issued under board orders	Issued under applications to comptroller	Totals
Lytton	98	40	138
Kamloops	64	15	79
Okanagan	26	11	37
Williams Lake	19	10	29
Kootenay	11	2	13
Stuart Lake	1		1
Vancouver		3	3
Babine	1		1
Naas		1	1
	220	82	302

All works required under conditional licenses which have been granted by the board will have to be carried out within the time specified under each license. This will require close engineering supervision for some years to come, so that the Department of Indian Affairs may reap the full benefit of water allotted to them.

Close co-operation was maintained with the British Columbia Lands Branch. Several reports with plans were submitted during the year covering applications to purchase lands in the British Columbia Railway Belt.

In co-operation with the Soldier Settlement Board, a report was prepared on a proposed irrigation system near Kamloops.

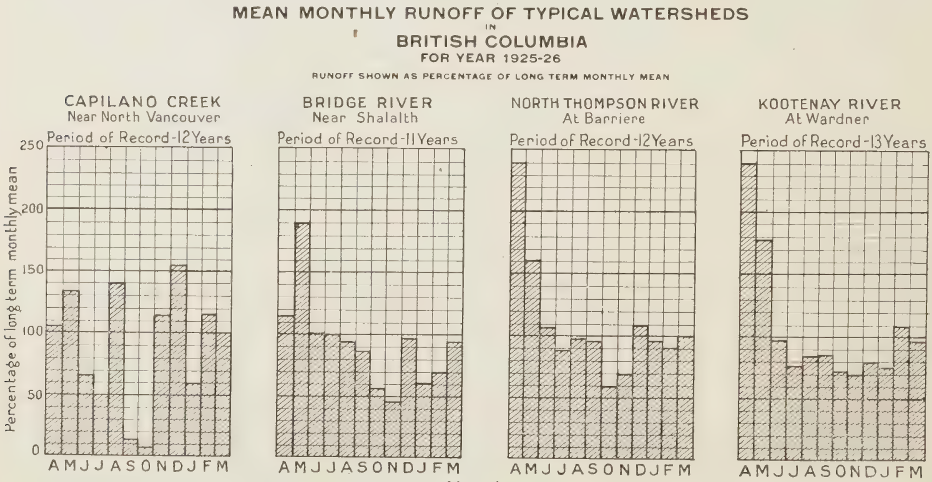
HYDROMETRIC SURVEY

One hundred and eighty-six regular gauging stations were maintained on rivers and tributaries during the year ended March 31, 1926, in the following main watersheds: Columbia, Fraser, Kettle, Kootenay, North Thompson, Okanagan, Pacific Coast (Mainland) Similkameen, South Thompson, Thompson, Lillooet and Vancouver Island. Many of these stations were maintained for more than one purpose, 68 were maintained for power, 129 for irrigation, 18 for drainage and reclamation, 5 for domestic water supply, 8 for flood purposes, 15 for navigation, 18 for international problems, and 5 for statistical purposes. There were 12 new stations established and none discontinued. Of the new stations, 6 were established at the request of the provincial Water Rights Branch, in connection with water-power investigations and irrigation problems throughout the province; two were established on behalf of the Department of Indian Affairs in connection with a drainage problem; three were established in connection with the Kootenay Lake Study; and one was established on behalf of the British Columbia Lands Branch in connection with an irrigation application.

The temperature throughout British Columbia during the past year has been above normal. The precipitation for the year has been very appreciably below normal, except in the Kamloops district, where it was 97 per cent of the mean for the past thirty-three years.

In the Coastal area, the total run-off for the year ended March 31, 1926, was below normal; the run-off in the Central Fraser area was about normal; and in the North Thompson and Kootenay areas above normal. The following are four typical stations in the Pacific Drainage; Capilano creek near Vancouver, Bridge river near Lillooet, North Thompson river at Barriere, and the Kootenay river at Wardner (*see* Plate 1).

PLATE 1



In the Coast area, as typified by Capilano creek, which has a drainage area of 64 square miles, low precipitation and run-off were recorded, the former being 82 per cent of the long-term mean, and the latter 88 per cent. Flood run-off

reached a maximum daily mean discharge of 128 second-feet per square mile in December, as compared with 264 second-feet in October, 1921. The low run-off, which occurred in October (the lowest ever recorded) was at the rate of 0.47 second-foot per mile, as compared with 0.56 second-foot, in September, 1915 and 1923, the minimum discharge previously recorded during the past eleven years.

In the Central Fraser basin, as typified by Bridge river, which has a drainage area of 1,900 square miles, both precipitation and run-off were below normal, the former being 71 per cent of the long-term mean and the latter 92 per cent. The flood run-off reached a maximum daily mean discharge of 8.32 second-feet per square mile in June, compared with 13.7 second-feet in June, 1913. The low run-off, which occurred in December (the lowest ever recorded) was at the rate of 0.13 second-foot per square mile, as compared with the previous low in the eleven years of record of 0.189 second-foot in November, 1918.

In the North Thompson River basin, as typified by the North Thompson river at Barriere, which has a drainage area of 7,000 square miles, the yearly precipitation was slightly below normal, being 97 per cent of the long-term mean. The yearly run-off was above normal, being 110 per cent of the long-term mean. The flood run-off reached a maximum daily mean discharge of 9.83 second-feet per square mile in May, compared with 11.16 second-feet in June, 1921. The low run-off, which occurred in February, was at the rate of 0.343 second-foot per square mile, as compared with 0.214 second-foot in March, 1919, the minimum discharge recorded during the past eleven years.

In the Upper Kootenay basin, as typified by the Kootenay river at Wardner, which has a drainage area of 5,200 square miles, the yearly precipitation was below normal, being 66 per cent of the long-term mean. However, due to higher temperatures being experienced throughout the whole year and particularly in the months of April and May, the yearly run-off was above normal, being 116 per cent of the long-term mean. The flood run-off reached a maximum daily mean discharge of 9.19 second-feet per square mile in May, as compared with 13.0 second-feet in June, 1916. The low run-off which occurred in January, was at the rate of 0.23 second-foot per square mile, as compared with 0.12 second-foot in January, 1914, the minimum discharge recorded during the past twelve years.

SPECIAL INVESTIGATIONS

Hydrometric investigations in close co-operation with the city of Vancouver, the Greater Vancouver water district and others in co-operation with the British Columbia Electric Railway Company have already been referred to. Now that the Greater Vancouver water district has been formed it is the intention of the commissioner to have an intensive study made, in co-operation with this service, of the storage possibilities in Capilano and Seymour creeks in anticipation of the future development of the water system to supply the cities of North Vancouver and Vancouver, as well as the several surrounding municipalities.

An intensive study of the water supply and hydraulic factors of Kootenay lake and river was undertaken in connection with power and reclamation projects on the Kootenay river and their possible effect upon International waters.

British Columbia Lands Branch.—Three investigations were made on behalf of the British Columbia Lands Branch of the Department of the Interior. Typical of these is that covering the application of the Ashcroft Water, Electric and Improvement Company, to purchase land, under irrigation conditions, in the British Columbia Railway Belt.

Department of Indian Affairs

Fifty surveys and investigations were conducted during the year on behalf of the Department of Indian Affairs. These investigations covered a wide range in engineering, including water storage, irrigation, reclamation, domestic water supply and electric lighting systems for Indian industrial schools and Indian reserves.

Where required, plans, estimates of cost and specifications have accompanied reports on proposed works for the consideration of the department, and several agreements covering the construction, maintenance or operation of works owned, or used, jointly with other interests, have been prepared. Several projects were satisfactorily completed during the year and numerous works consisting of alterations or improvements to existing systems were carried out.

Of the above projects, the following typical works may be described:—

Water Storage.—Additional storage amounting to 130 acre-feet for irrigation purposes was provided at Botanic lake by raising the existing dam six feet. This project necessitated the preparation of plan of project for the approval of the Comptroller of Water Rights, and involved the placing of 3,600 cubic yards of material in the dam, as well as spillway construction, the excavation of one-quarter mile of ditch and the installation of headworks in Huckleberry creek.

Irrigation.—An irrigation system was built to serve 200 acres of Clinton Indian reserve No. 2, from Kelly creek, consisting of intake works, 6,000 feet of ditch and 2,300 feet of flume. This system was designed to carry about 3 second-feet of water.

Diversion Works.—A concrete diversion work with measuring weirs and headgates was constructed on Paul creek for proportioning the flow of water between the Western Canada Ranching Company and Kamloops Indian reserve No. 1.

Domestic Water Supply.—A complete study was made of a domestic water supply system to supply the new Kamloops industrial school near Kamloops. This proposed water supply system includes the construction of a reinforced concrete reservoir of 18,000 gallons capacity, a reinforced concrete pump-house wherein it is proposed to install a 500-United States gallon per minute centrifugal pump directly connected to a 60-hp. motor, as well as the laying of some 2,700 feet of 8-inch supply pipe. It is proposed to install complete fire-fighting equipment.

Electric Lighting.—An investigation has been made of a proposed hydro-electric lighting system for the Indian village at Churchhouse Homalco Indian reserve No. 6, which provides for the construction of a diversion dam and the installation of a water-wheel and generator in a suitable power-house.

There is a continued call for hydrometric data on power streams throughout the province. With the increasing settlement of the dry-belt of the interior the water situation for irrigation purposes is becoming more acute and, as time goes on, hydrometric records on irrigation streams are being utilized more and more in the adjustment of water rights and in the distribution of water for irrigation. Hydrometric data have been in request by most of the larger cities of the province as well as the Board of Fire Underwriters, concerning questions of water supply and fire protection.

DISTRICT OF ALBERTA AND SASKATCHEWAN

A. L. Ford, District Chief Engineer

The stream measurement and power investigatory work of the Dominion Water Power and Reclamation Service in Alberta and Saskatchewan was continued in conjunction with the irrigation and drainage activities, referred to in Part II of this report, during the fiscal year ended March 31, 1926.

From this district office the whole of the province of Alberta, most of the province of Saskatchewan and a small portion of northeastern British Columbia is covered. Owing to lines of communication being through Alberta, the Peace River block in British Columbia is handled from this office, and for a similar reason the northeastern or Churchill River area in Saskatchewan is handled from the Manitoba office of this service.

ORGANIZATION

All the functions in regard to the investigation, utilization and administration of water resources in the provinces of Alberta and Saskatchewan are carried out by a single field organization with headquarters at Calgary, Alberta. As a matter of economy in covering this large territory, subdistricts have been created and each placed under the charge of an engineer who carries on the hydrometric field investigations as well as those of irrigation, drainage or water-power. These officers report to Calgary where all data are collected, compiled and filed.

CO-OPERATION

During the year the same co-operative arrangements with the Montana division of the United States Geological Survey and the United States Bureau of Reclamation in regard to the collection of stream-flow records on international waters along the boundary between the provinces of Alberta and Saskatchewan and the state of Montana were continued. These duties devolve on this service through the requirements of the International Joint Commission under the provisions of the Boundary Waters Treaty of 1909. It is desired to record the very friendly and helpful co-operation afforded each year by members of the United States services in connection with this work.

Looking to the solution of problems in connection with the irrigation systems of the Canadian Pacific Railway Company in Alberta, there has been mutually advantageous co-operation between our staff and the officials and engineers of the company.

Active co-operation was carried out with the Lethbridge Northern irrigation district in investigating hydrometric problems in connection with the operation of that project.

The usual co-operation with officials of other irrigation and power projects in regard to stream and canal-flow problems was continued with excellent results.

The co-operative arrangements carried out with other federal departments, the provincial governments, railway corporations and several municipalities have been continued and extended during the year. Many problems in regard to their water supply questions have been studied, and with their assistance valuable hydrometric data have been obtained which are not only of special interest to them but also of general value.

Again during the past fiscal year the lectures and demonstrations on hydrometric and water-power methods were carried out at the University of Alberta and the University of Saskatchewan. At the University of Saskatchewan active assistance was given in the way of advice and loan of equipment in connection with a study of run-off from prairie areas.

HYDROMETRIC SURVEY

In the fiscal year ended March 31, 1926, 265 gauging stations were maintained for various periods on streams, lakes, canals or ditches in the following main drainage basins: Athabaska, Battle creek, Belly, Bow, Frenchman, Little Bow, Lodge creek, Milk, North Saskatchewan, Oldman, Peace, Qu'Appelle, Red Deer, Rock creek, Ross creek, St. Mary, Saskatchewan, Sevenpersons creek,

South Saskatchewan, Swiftcurrent creek and Waterton. It will be noted that there has been a decrease in the number of stations operated over previous years, due to the discontinuation of stations on a large number of private irrigation schemes where the water supply question is not acute. Of the stations 12 on streams and 2 on lakes or reservoirs were operated throughout the year for power purposes. In connection with irrigation studies 12 stations on streams were maintained throughout the year. In addition, 52 on streams, 11 on lakes or reservoirs, 30 on canals and 55 on ditches were maintained during the irrigation or open-water season only. One station on a stream was maintained the whole year for drainage purposes while 13 on streams and 8 on lakes were maintained during the open-water season only. Three stations on streams, and 1 on a lake were maintained throughout the year, and 9 on streams during open-water only, for collection of information in connection with domestic, industrial or municipal water supply problems. During the flood-danger period stations maintained for other purposes were augmented by 4 stream stations and 2 lake stations for flood warning service. To carry out the instructions of the International Joint Commission it was necessary to maintain 4 all-year stations on streams, with 13 stations on streams, 1 on a reservoir, 3 on canals and 15 on ditches during the open water season only. Six stations were maintained on streams throughout the year and 3 on streams and 5 on lakes during open water only for statistical purposes. In addition varying numbers of miscellaneous discharge measurements were made at 91 points in both provinces.

Following unusually heavy snowfalls during the winter of 1924-25 the early run-off in Alberta and the southern half of Saskatchewan was well above average. In southern Saskatchewan streams reached flood stages in the last few days of March or first few days of April, and at the beginning of the present fiscal year were all well above average. The run-off during the summer was, generally speaking, below average but heavy general rains in August and snows in September brought up the run-off at that period towards average and in some cases above average. This early snowfall was followed by a winter of unprecedented mildness with a light snowfall. Run-off remained high, however, probably due to the small spring-fed streams, which are one of the chief winter sources of supply, remaining open. An early break-up in March closed the year under review. On the whole the run-off for the year was below average although streams in southwestern Alberta show run-off above normal. No floods other than those which occurred in southern Saskatchewan at the end of the previous or opening of the present fiscal year were reported and no new maximum run-off was recorded during the year in either province.

Of special interest, and, worthy of record, was the unusually mild winter of 1925-26. During September and October the precipitation was above average with low temperatures. Following this storm period the winter was unusually mild with light precipitations so that the snow on the ground at the opening of spring was well below average. In fact, for the winter months, the snowfall at Banff in the mountain area was the lowest on record, being only 15 inches compared with 61.6 inches for the same months during the winter of 1924-25. The lowest recorded temperature at Banff for the winter 1925-26 was —6° F., and for the top of Sulphur mountain near Banff, —10° F. The same condition as to precipitation and temperature was noted in almost all parts of Alberta and Saskatchewan, and as a result the mean temperature for the year was approximately 10 per cent above average. Many mountain streams remained open all winter and in southern Alberta none had complete ice cover for more than a week or two. Peace river in northern Alberta broke up in December and remained open for a considerable time. Much of the spring run-off for 1926 occurred during early March in all southern portions of the district, approximately one month earlier than in 1925.

Graphs showing the run-off, month by month, for typical streams indicative of general conditions in Alberta and Saskatchewan accompany this report. (See Plates 2 and 3). The Belly river near Mountain View is shown as representative of the southern area of Alberta; the Elbow river at Calgary covers the south central area; the Clearwater river near Rocky Mountain House the north central area; and the Peace river at Peace River, the northern area. The representative streams chosen for Saskatchewan are, for the Cypress Hills or southwestern area, Battle creek at Tenmile; for the southeastern area Moosejaw creek; for the northeastern area, Carrot river; and for the northwestern area, Battle river near Battleford.

PLATE 2

MEAN MONTHLY RUNOFF OF TYPICAL WATERSHEDS IN ALBERTA
FOR YEAR 1925-26
RUNOFF SHOWN AS PERCENTAGE OF LONG TERM MONTHLY MEAN

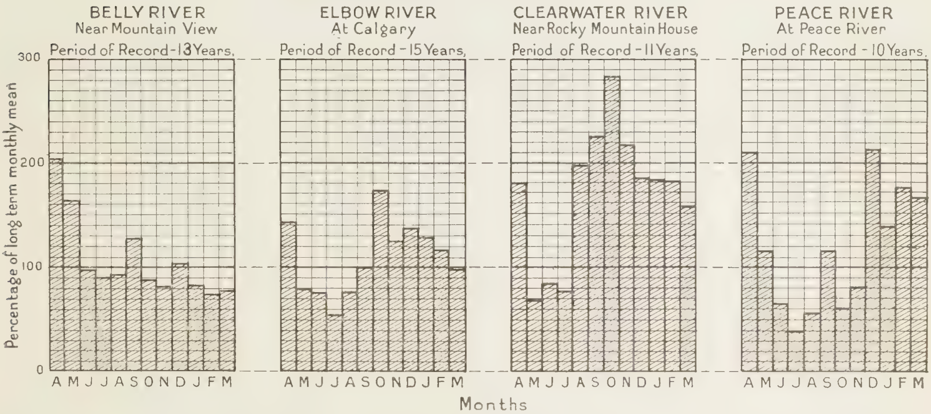
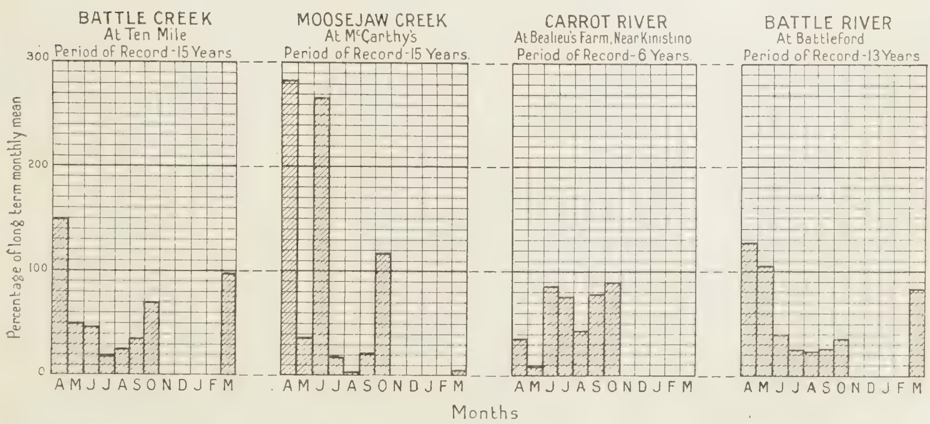


PLATE 3

MEAN MONTHLY RUNOFF OF TYPICAL WATERSHEDS IN SASKATCHEWAN
FOR YEAR 1925-26
RUNOFF SHOWN AS PERCENTAGE OF LONG TERM MONTHLY MEAN



The run-off in Alberta as shown by the typical stations varied from the long-term mean as follows: Belly river, 113 per cent; Elbow river, 89 per cent; Clearwater river, 139 per cent; and Peace river, 83 per cent. Precipitations in Alberta as shown by typical stations varied from 107 per cent to 117 per cent of average in the southern portion of the province. In the north the precipitation was below normal and for Edmonton was 90 per cent of the long-term average.

The records show that the annual run-off in Saskatchewan, was, on the whole, again below average, Battle river near Battleford being 68 per cent of the long-term average; Carrot river, 34 per cent; Moosejaw creek, 192 per cent; and Battle creek, 88 per cent. Precipitations, as shown by typical stations in Saskatchewan, ranged from 84 per cent to 114 per cent of the long-term mean in the south and from 89 to 99 per cent in the north.

The only fully equipped current-meter rating station in Canada is operated by this organization at Calgary. Here all instruments used by this service and by many other organizations are rated. At the station, meters are rated as received from the field which provides data on which to recompute recent measurements made with the particular instrument under test, should such action be necessary. Following the first rating, the instrument is checked over, and, if necessary, repaired by our staff and again rated before being returned to its user. During the fiscal year 1925-26 from May 15 to November 3, a total of 93 current-meters were received for rating, 135 ratings made and 50 instruments repaired to some extent, and in addition certain equipment was rebuilt, a new woven-wire fence placed around the property, the track completely relaid on new ties and new planking put in place. Of the meters rated, 4 were for the Department of Marine and Fisheries, 10 for private interests and the remainder were forwarded by offices of this service as follows: Quebec, 4; Ontario, 25; Manitoba, 6; Alberta and Saskatchewan, 29; British Columbia, 15. Early in the season some most interesting ratings were made on meters to determine their behaviour under turbulent conditions. This work was done in connection with field investigations being carried out at Niagara, Ont., and required the construction of several special pieces of rating equipment.

SPECIAL INVESTIGATIONS

Since 1921 this service has annually taken charge of the operation of the storage reservoir at lake Minnewanka in Banff National park during the filling season, which is also the tourist season. Following this practice, the control of operations at the dam at the outlet of this lake was assumed on May 8, 1925, and continued until October 6. During this period the lake was quickly raised to the level desired by the Canadian National Parks officials and held between that point and upper regulation level until the end of the tourist season. Just before the close of the tourist season a tentative agreement was reached between the officials of the Calgary Power Company, who use the storage created, and those of the Canadian National Parks Branch for the raising of the level of the outer section of the wharf at lake Minnewanka. This work, which is to be carried out while the lake is low in the spring, will, as well as generally improving boating conditions, tend to lessen the difficulties of operation.

An inspection was made of the water-power plant of the Canadian Pacific Railway Company on Louise creek at lake Louise, where an extension of the power-house had been made and new units added.

The two applications, that of the Montreal Engineering Company of Montreal, P.Q., and that of the Province of Alberta, for the right to develop storage and high-head power at Spray lakes in the Bow River basin are still before the department.

Numerous requests, mostly from northern Saskatchewan and northern Alberta as to small-power sites, and as to the necessary form of application, etc., have been received and the information supplied. One inspection and report on a small-power site was made during the year.

The power shortage in the cities of Calgary and Edmonton is becoming more acute as the consumption of power increases year by year. At Edmonton the civic officials recognize that it will be necessary to increase the stoker and

generator capacities at the municipal steam plant in the near future and to replace the plant by a more modern one in about five years, unless, meanwhile, some other source of comparatively cheap power is found.

At Calgary, the Calgary Power Company's two hydro-power plants on the Bow river at Seebe, together with the municipal steam plant, used as a stand-by, have been pressed to meet the peak power load when, as at the beginning of 1926, this was combined with low flow in the Bow river. The company is increasing the efficiency of the plants by replacing the runners in one turbine, rewinding two generators, and with the assistance of officials of this service rating all their units at both Kananaskis Falls and Horseshoe Falls plants for over-all efficiency so that the greatest possible quantity of power may be obtained from the available water supply. The above mentioned changes in plant equipment are the result of a test made by this service early in the fiscal year. The company is also, with the advice and assistance of the service's officers, installing long distance water stage recorders and in all possible ways arranging to check the available water supply against the power output so that all inefficient methods of operation may be eliminated. At the same time the Calgary substation equipment has been re-arranged and added to, partly owing to the construction of the third transmission line from the hydro-plants in 1924 and partly in order to decrease transformation losses and provide more reliable service to the city of Calgary.

The investigation of absorption losses in lake Newell reservoir of the eastern section of the Canadian Pacific Railway Company's irrigation system, started in 1920, was continued in conjunction with the officials of that organization. The progress reports of this investigation covering the work done in the years 1924 and 1925 were completed and a final report covering the work to date is under course of preparation.

The investigation of carriage losses on the main canal of the western section of the Canadian Pacific Railway Company's irrigation system was again made in co-operation with company officials. This investigation has been carried on for the past four seasons and it is considered that it is now completed and a final report is being prepared.

Two distinct investigations were carried out on the Lethbridge Northern Irrigation District system. The first was an investigation of carriage losses on the main canal from the headgates to below the Willow Creek flume. Many valuable data were obtained as to the losses in various classes of material through which this canal passes. The second investigation was of the losses in Keho Lake reservoir. Progress reports covering the findings have been prepared and submitted.

Again in May the investigation of snow conditions in the Upper St. Mary basin was carried out jointly with the district engineer of Montana Division of the United States Geological Survey. This investigation is gradually accumulating some very useful data on which may be based estimates of the probable seasonal run-off of the St. Mary river which is a most important international irrigation stream.

Although the demand for irrigation data has not been great during the past two years owing to the precipitation being normal or above normal, there has been a marked increase during the past fiscal year in the number of requests received for hydrometric data. This is due to the fact that gradually the public are becoming aware that these data are available. In addition to the requests for ordinary stream-flow records, this service receives and supplies a large number of requests for miscellaneous data such as temperatures, precipitations, water levels, and other information touching on our work. During the fiscal year records for 315 gauging stations were supplied as well as much other data of a power or hydrometric nature. Warnings as to high-water conditions

on the North Saskatchewan river during August were issued to municipal authorities along that stream. In connection with this work predictions of the water levels to be expected were made with a remarkable degree of accuracy and materially increased the value of the information supplied.

DISTRICT OF MANITOBA

C. H. Attwood, District Chief Engineer.

During the fiscal year ended March 31, 1926, the regular stream measurement and power investigatory operations of the Dominion Water Power and Reclamation Service in Manitoba and adjacent districts have been continued.

The scope of the work covered by this district organization comprises the hydrometric, power, storage and reclamation investigatory work in Manitoba and the Churchill River section of northeastern Saskatchewan, and also the hydrometric work in that portion of western Ontario inclusive of, and lying to the west of the Nipigon river.

ORGANIZATION

The local organization of the Dominion Water Power and Reclamation Service, with headquarters at Winnipeg, was organized in 1912 and the work then instituted has been carried on and extended from time to time. The duties of the engineers and the hydrometric recorders consist of both field and office work, including surveys, investigations, inspection and supervision of construction, and the preparation of the data collected in report form, for submission to the head office.

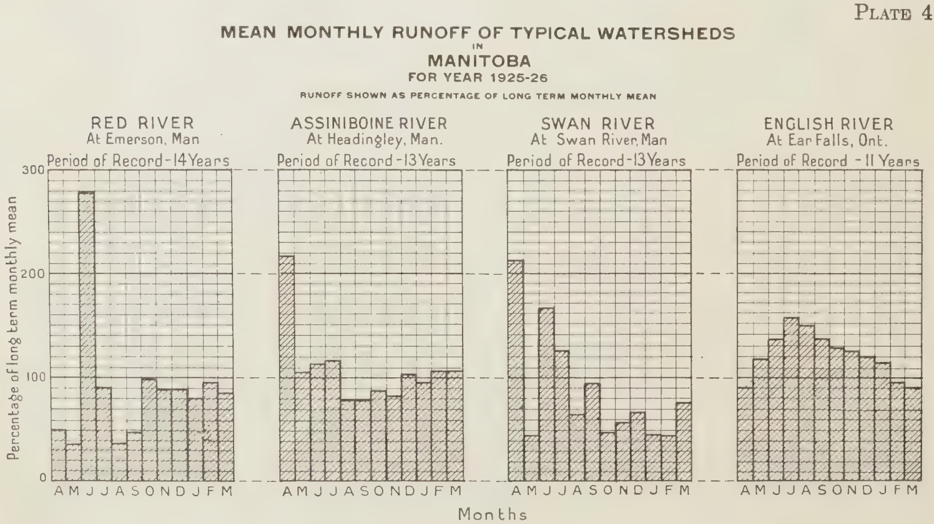
CO-OPERATION

The organization works in co-operation with several departments of the federal Government and with the Power Commission and the Reclamation Service of Manitoba.

HYDROMETRIC SURVEY

During the past year 96 regular and 24 miscellaneous stations have been maintained on lakes, rivers and tributaries in the following main watersheds: Nelson river, lake Winnipeg, Winnipeg river, lake of the Woods, Rainy lake, English, Red, Assiniboine, Dauphin and Saskatchewan rivers.

PLATE 4



Of the above regular stations, there were maintained for power and storage 50 all year, 3 during open water and 7 miscellaneous; for drainage and reclamation throughout the year, 10 regular and 17 during open-water and 17 miscellaneous. Five regular all-year stations were maintained for flood study. On international streams 11 all-year and 4 open-water regular stations were maintained, together with 4 miscellaneous. For water supply, 5 regular stations were maintained during open-water, and for statistical purposes 5 all-year stations. Eleven meteorological stations were maintained continuously. In the above classification a number of stations have been maintained for more than one purpose.

In analyzing the hydrological conditions for the year, four streams have been selected as typical of conditions in their respective districts and the run-off data have been analyzed as shown in the accompanying chart (Plate 4). In the southwestern and midwestern sections of the province, as exemplified by the Assiniboine and Swan rivers, the average run-off was above the mean, being respectively 122 and 125 per cent of the mean for the years of record. The flood run-off did not, however, reach a maximum rate; that of the Assiniboine being 0.231 second-foot per square mile, or 63 per cent of the previous maximum, and the Swan 6.535 second-feet per square mile, or 94 per cent of the previous maximum. The minimum run-off occurred during the winter months with 0.004 second-foot per square mile on the Assiniboine and 0.003 on the Swan. Both of these exceed the previously recorded minimums which were 0.001 and 0.00 respectively.

Precipitation during the year in the above areas ranged from 78 per cent of the long-term mean in the Assiniboine watershed to 99 per cent of the mean in the Swan River watershed.

In the southerly portion of the province, as typified by the Red river, the run-off was below normal, being 86 per cent of the mean with the precipitation on the water-shed 108 per cent of the long-term mean. The run-off during flood, 0.506 second-foot per square mile, was low, being only 38 per cent of the previously recorded maximum. The minimum for the year was 0.010 second-foot per square mile in September, compared with 0.003, the minimum for the period of record.

In the Laurentian area in the southeasterly portion of Manitoba and the extreme westerly section of Ontario, run-off as typified by the English river, was above normal, being 125 per cent of the long-term mean, while precipitation was 109 per cent of the mean. The rate of run-off was 1.256 second-feet per square mile, being 70 per cent of the recorded maximum, while the minimum was 0.316 second-foot per square mile, compared with 0.263, the lowest recorded.

During April 1925 the Assiniboine river again overflowed, due entirely, however, to ice jams, as the discharge was only half of that during the floods of 1922 and 1923. Flooding also occurred during July on the Roseau river. Both of these floods are dealt with under the heading " Special Investigations ".

On the Whitemouth and Birch rivers flooding also occurred due to the heavy precipitation during June. A large area was inundated and the settlers in the district, in addition to the loss occasioned, suffered great hardship in being cut off from any source of supplies, as transportation to or from the district, except by boats, was impossible.

SPECIAL INVESTIGATIONS

During the year investigations were greatly curtailed, only the most urgent being undertaken. These are as follows:—

Assiniboine River Flood

For the third time in four years flooding occurred on the Assiniboine river during the break-up period. The flood in March and April last differed how-

ever from the past two, in that the flooding was caused, not by an excessive run-off, but entirely by ice jams in the river.

With the early thaw the river, while still covered with a thick ice sheet, was called upon to carry the spring run-off. With the movement of the ice serious jams occurred at some points causing the river to overflow its banks. Fortunately the snowfall on the Assiniboine watershed was very little above normal, otherwise extensive flooding would have occurred. The discharge never exceeded 11,000 c.f.s., which is only one-half that of the flood periods in 1922 and 1923.

On March 29, the ice started jamming at the Midland Railway bridge southeast of the city of Portage la Prairie and the river rose over five feet. By April 1, a further rise of six feet caused the river to overflow its bank southwest of the town.

An inspection of conditions at Portage la Prairie was made during the afternoon of April 1, when it was found, due to the ice jam having been partially broken, the water was falling, and by 9 p.m. it had lowered $1\frac{1}{2}$ feet at the Canadian Pacific Railway culvert, 2 miles west of the city. Though the river south and west of the town was still packed bank high with hard thick ice, no further increase in stage occurred and by April 3, the continuous efforts to break the jam were successful in lowering the river sufficiently to stop all overflowing of its banks.

Between Portage la Prairie and Brandon there was no flooding. In Brandon and westerly, however, the low flats of the valley were partially submerged, causing a certain amount of damage, particularly in Brandon, where a number of houses were flooded to the first floor.

On the stretch of the river from Winnipeg to Poplar Point no flooding took place; in the city of Winnipeg serious ice jams formed, but prompt measures taken in breaking them prevented any overflowing of the river.

Roseau River Flood

In June and July flooding occurred along the Roseau river in Manitoba and Minnesota, caused by the heavy precipitation and by the rapid run-off from the Roseau Drainage district in the state of Minnesota. In Manitoba the low-lying lands adjacent to the river in townships 1, 2 and part of 3, ranges 6, 7 and 8, were flooded, the flooding extending westward some 5 or 6 miles, and on the east side to the valley of the Rat river, a distance of about 10 miles, completely destroying the hay, root and grain crops.

While a portion of the low-lying lands adjoining the river in Manitoba are flooded each year to some extent during the spring break-up, apparently these early spring floods do little or no damage to the crops as the water is generally gone before growth is started. The later floods of June and July destroy the root, hay and grain crops and the livelihood of the farmers. These later floods are largely increased by the rapid run-off from the Roseau Drainage system in the state of Minnesota, and numerous petitions have been received from the settlers in this area for protection and relief from the increasing flood menace.

Following the flood of last July an inspection tour of the entire Roseau River drainage basin was organized by the Hon. W. R. Clubb, Minister of Public Works, Manitoba, who was accompanied by Mr. D. L. McLean, Deputy Minister of Public Works, Manitoba; Mr. E. V. Willard, Commissioner of Drainage Waters, Minnesota; Mr. G. Affleck, District Engineer, Manitoba Reclamation Branch, and Mr. Attwood. Starting from Emerson on the morning of August 27 the route of the inspection included Dominion City, Greenridge, Rapids of the Roseau, Stuartburn, Vita, section 24, township 1, range 7, east, in Manitoba; and Caribou, Greenbush, Badger, Fox, Mud lake, Roseau lake,

Ross, Duxey; the drainage areas of Polonia, Barto, Juneberry and Soler townships in the state of Minnesota. In the Roseau Drainage district in Minnesota approximately 1,000 miles of drainage ditches have been constructed and the river channel has been enlarged for the greater part of its course from Roseau lake down to the International Boundary. These ditches, laterals and channel improvements were constructed with the object of draining the marsh land in the upper Roseau basin, and in doing so they greatly accelerated the run-off into the river below. Upon reaching Manitoba, where the river channel has not been improved and has not sufficient capacity to handle the increased volume of water pouring in from the south, it caused excessive high stages which resulted in flooding of the land mentioned above.

The inspection of the entire river basin in August last showed that on a large portion of the watershed in Minnesota additional drainage works would be required before the lands could be reclaimed for farming purposes. It showed also that a scheme of flood prevention was necessary to carry off the precipitation so quickly discharged by the drainage system. Such a scheme, however, requires an adequate outlet, and this can only be found in Manitoba. The stream-flow records and the experience of the past ten to fifteen years show that the Roseau river channel in townships 1 and 2, ranges 6, 7 and 8, is inadequate to handle the flood water from Minnesota.

With further extensions to the drainage system in Minnesota the volume of flood water which will be discharged into Manitoba will probably be greatly increased and flooding more extensive and destructive unless some system of protection works is provided. The country adjoining the Roseau river in Manitoba is fairly well settled and becoming more so each year. As the land becomes improved and more of it placed under cultivation the damage caused by floods becomes greater year by year and the need for a satisfactory solution of the problem more pressing.

Guy Indian School—Sturgeon Landing, Saskatchewan

At the request of the Department of Indian Affairs an investigation was made of the Sturgeon river at Sturgeon Landing to determine the feasibility of a hydro-electric development for supplying power to the Guy Indian residential school, then under construction, in connection with lighting, water supply, etc. The investigation showed however that the cost for a hydraulic power plant would be excessive for the small amount of power required and it was recommended that oil engines be used to generate the necessary power. In addition to this investigation a report and plans were prepared for the Department of Indian Affairs covering the installation of a lighting plant, and a water-supply and sewerage system for the school.

Upper Rainy Boundary Waters

With respect to the reference to the International Joint Commission relating to the regulation and control of the water levels on Rainy and Upper Boundary lakes, a survey was made of the waterfront on Indian reserve No. 25-D, situated on the north shore of lac la Croix. The survey party started work in July and continued to the end of October. The survey was made at the request of the Department of Indian Affairs to determine to what extent Indian reserve 25-D would be affected by raising the level of lac la Croix. To this end instructions were given to locate the contours from the shore line up to contour 1,200 and obtain a timber and land classification within this area, together with a valuation of buildings affected. These data were necessary to enable the Department of Indian Affairs to reply to the questionnaire sent out by the International Joint Commission.

In addition to the above survey, Mr. Attwood met Mr. S. S. Scovil and Major Crawford, the engineers appointed to the International Joint Commission for this reference, and Mr. R. S. Lea, consulting engineer to the Winnipeg power interests, in Duluth on September 12 and proceeded on an investigation of several of the Boundary lakes. Arriving at Fort Frances on September 25 an investigation was made of the river frontage at Fort Frances and International Falls, Pither's Point, Ranier and the Canadian National Railway crossings and grades on Rainy lake, following which the party remained at International Falls and was present at the hearings held there by the International Joint Commission on September 28, 29 and 30.

Bowstring Lake Diversion

Following the receipt of a despatch under date of April 1, 1925, from the Secretary of State of the United States advising that an injunction had been issued by the United States District Court of Minnesota restraining the continuance of the diversion of water from Bowstring lake in Minnesota, the Lake of the Woods Control Board, at a meeting held in July, requested that Mr. Attwood arrange for an inspection on the ground to ascertain whether the order of the court had been complied with. An inspection of the Bowstring Lake diversion was made on August 11 and showed that the order of the court had been complied with. At a point along the ditch about two miles from the lake the ditch had been completely filled with earth for a distance of some 200 feet, effectively preventing all diversion from Bowstring lake.

Catfish Creek Drainage

No actual progress was made with construction on this project during the year. The building of a railway branch line from Beaconia to the Manitoba Pulp and Paper Company's mill site on the Winnipeg river in the vicinity of Pine falls, which cuts through a portion of this drainage area, will greatly facilitate transportation of dredging equipment and provide easier access to the work. The applicants have, however, made progress with the project in that they have employed a firm of drainage engineers and surveyors to make a complete contour survey of the entire area and prepare plans and a report outlining an adequate system of drainage. The survey parties have been actively engaged for the past three or four months and present indications are that the construction of this project will be commenced at an early date.

Whiteshell River

Following an application to the Service for water-power rights on the Whiteshell river in Manitoba with the object of developing power at the two lower falls on the river to operate a small milling industry, a reconnaissance survey of the proposed power site, located in the southwest quarter of section 34, township 13, range 14, E.P.M., was made in September.

The data necessary for a study of conditions covered by the application were obtained by a stadia traverse run on magnetic bearing from the foot of the first fall to the head of the second fall, hand-level cross-sections being secured at each of the traverse stations on both sides of the river. Check levels were run from the lower fall up to Birch lake to determine the total drop in this stretch of the river and the storage possibilities of Birch lake.

A head of 25 feet may be concentrated at the site which with the estimated flows and an over-all efficiency of 80 per cent would produce 73 h.-p. at ordinary minimum flow, and 218 h.-p. for the 6 high months, 24-hour power. Birch lake, situated about 4 miles up stream, could be utilized to conserve and regulate the flow and under normal working conditions practically double the power available.

At present there is no indication that the applicant will proceed with the development of this site.

CONSTRUCTION

Lake of the Woods—Western Outlet

The enlargement of the western outlet of the lake of the Woods and the reconstruction of the Norman dam was proceeded with during the year in accordance with the agreement between the Department of the Interior and the Keewatin Power Company. The rock excavation required for the enlargement of the western outlet was completed early in October, some 52,600 cubic yards or rock having been excavated from the channel. About one-half of the rock was used to form training embankments and to fill up deep holes in the channel so as to improve flow conditions; the remainder of the excavated rock was wasted in the rear of the training embankments. This work was carried out in conjunction with the reconstruction of the Norman dam and the erection of the power-house, and it was not until January 18 that this latter work was sufficiently advanced to permit of the passing of the water into the western outlet through the cofferdam. By February 20 the cofferdam at the head of the western outlet had been removed and at the end of March all temporary buildings and construction work required for the channel enlargement had been removed.

In April, 1925, work was commenced on the rock excavation necessary for the substructure of the power-house at the site of the Norman dam and also upon the reconstruction of the dam. The work was carried on steadily throughout the year and was practically completed at the end of March, there remaining only a portion of the concrete deck slab to be placed on the dam. The construction work involved the repair of the masonry piers and wing walls of the old dam, the pouring of concrete aprons for the sluiceways of the dam, the framing and placing of new sets of stop-logs in the sluices, the laying of reinforced concrete deck slab along the entire length of the dam, the construction of a fish ladder, the removal of the old rock-fill dam to make way for the power-house the rock excavation work necessary for the foundations of the power-house and improved flow conditions in the forebay and tailrace, and also the construction and erection of the substructure and the superstructure of the power-house and the installation of the necessary machinery and equipment. The power-house is 304 feet long and designed to house seven units, each of 3,300 k.v.a. capacity. The initial installation consists of five units and these are now installed and connected up with the company's other power station on the eastern outlet by means of a wooden pole transmission line. The lower cofferdam was removed and Unit No. 1 was started up on January 28. The power will be mostly utilized to operate the Kenora Paper Company's paper mill in Kenora.

The channel improvement work along the western outlet was designed and laid out by the department's engineers and the work was completed under their direction and supervision. The work in connection with the reconstruction of the Norman dam and those portions of the power-house that had to do with the passage of water were carried out under the supervision of the department's engineers.

McIntosh Indian School

The contract for the construction of the hydro-electric development and the water supply system for the Indian school was let late in August and was practically completed by the end of the year.

The hydro-electric development comprises a concrete dam on the Canyon river at the outlet of Forest lake, with a 36-inch wood stave penstock carrying the water some 300 feet to the power-house on the shore of Canyon lake which contains a 30-hp. turbine belt-connected to a driving shaft which is in turn belted to a 17½ kw. generator, a pump which supplies water for domestic supply and fire protection, and to a driving shaft in the carpenters' shop above the power-house.

This work was carried out under the supervision of this office at the request of the Department of Indian Affairs.

Pointe Du Bois

The initial development of the city of Winnipeg's hydro-electric plant at Pointe du Bois provided for, in addition to the power-house, a dam consisting of non-overflow, free spillway, and rock-fill sections. Sluice sections for complete regulatory control were not provided for and the leakage through the rock-fill amounted to from 3,500 to 5,000 second-feet. The installation of Units Nos. 13 and 14, making a total installation of 89,000 h.-p., and the peak load demands on the system made it necessary, during periods of low flow, to conserve the leakage through the rock-fill section of the dam. With the power demands on the system during the winter of 1924-25 operating conditions were such that for the first time in the history of the plant water was not flowing over the spillway sections of the dam and as a temporary expedient flash boards were installed on the spillway sections. Conditions pertaining during the winter were such that direct ice pressure caused damage to the main spillway section.

In view of the above and as the power plant installation was rapidly approaching maximum capacity, the Hydro officials decided upon a program of construction which made provision for,

(*a*) The strengthening of the spillway structure.

(*b*) Placing a water tight seal on the front of the rock-fill section.

(*c*) The construction of five 25-foot sluice-ways on the westerly end of the main spillway.

Plans showing the design and details of these alterations were submitted to this service for approval, contracts for the work were let, and the work proceeded with and completed by December 31.

Great Falls

In November the Manitoba Power Company started on the construction of a transmission line from the power plant at Great Falls to the site of the pulp and paper mill of the Manitoba Pulp and Paper Company, situated on the Winnipeg river in the vicinity of Pine falls. The land necessary for the transmission line right of way was secured and the right of way cleared for a width of 100 feet and a temporary wood-pole line, supplying power at 22,000 volts, was constructed. This line was completed ready to supply power for construction purposes about the end of January.

In January last the company decided to install a third unit in the Great Falls plant and to raise the forebay level at the plant to elevation 812. Specifications have been prepared and tenders called for the installation of unit No. 3, together with the necessary transformers and other electrical connections.

Early in February a contract was awarded to the Canadian Engineering and Construction Company to clear the forebay of the Great Falls development between elevation 805 and 814. This work is being done according to the requirements of the service and the work of clearing is being rapidly proceeded with in order to get as much of the clearing completed and the timber removed as is possible before the spring break-up.

DISTRICT OF ONTARIO

S. S. Scovil, District Chief Engineer

During the fiscal year ended March 31, 1926, the regular stream measurement and power investigatory operations of the Dominion Water Power and Reclamation Service in the province of Ontario have been continued in accordance with the terms of the co-operative agreement of October 1, 1919, between the Department of the Interior and the Hydro-Electric Power Commission of Ontario.

ORGANIZATION

The work of the Ontario Hydrometric Survey was carried on under the direction of the district chief engineer with a head office at Ottawa. The greater part of the field operations were carried out by the field staff from the North Bay office. The hydrometric investigations in that part of the province west of and including the Nipigon river were, as in previous years, carried on under the direction of the district office at Winnipeg while three stations in the vicinity of Ottawa which, being in the province of Quebec would ordinarily come under the supervision of the district chief engineer at Montreal, were for reasons of economy handled by the Ottawa office.

CO-OPERATION

In pursuing the field and office investigations the closest co-operation has been maintained with the officers of the Hydro-Electric Power Commission of Ontario. Valuable assistance has also been given the engineers of the district by various persons and corporations interested in the securing of hydrological data. In particular, reference should be made to the co-operation carried on with the following companies: the Abitibi Power and Paper Company; the International Nickel Company of Canada, the Kaministiquia Power Company, the Mattagami Pulp and Paper Company, the Mississippi River Improvement Company, the Pigeon River Lumber Company, the Spanish River Pulp and Paper Company, the Spruce Falls Company and the Northern Ontario Power Company.

HYDROMETRIC SURVEY

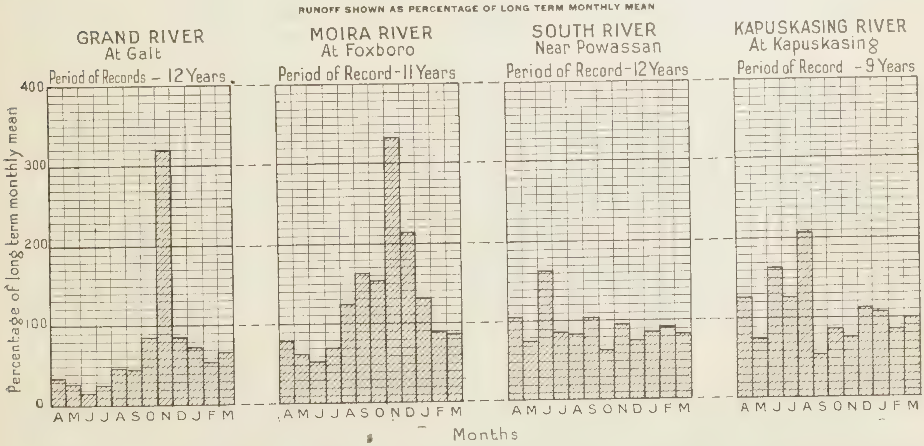
During the past year 59 regular stations were maintained on rivers and tributaries in the following main watersheds: Hudson Bay, Lake Superior, Lake Huron, Lake St. Clair, Lake Erie, Lake Ontario and Ottawa River.

Of these 50 were maintained throughout the year for power purposes. Five were maintained throughout the year and two during spring runoff for flood study; one for the purpose of domestic water supply and one on an international power control problem.

PLATE 5

MEAN MONTHLY RUNOFF OF TYPICAL WATERSHEDS IN ONTARIO FOR YEAR 1925-26

RUNOFF SHOWN AS PERCENTAGE OF LONG TERM MONTHLY MEAN



With the exception of the northern district the average run-off throughout the province for the year was below normal. This is illustrated by the accompanying graph (Plate No.5) showing the monthly run-off as a percentage of the average flow over a number of years.

In the southwest portion of the province the records of the Grand river at Galt, which is typical of the general run-off conditions of the district, show an average run-off for the year of 0·511 second-foot per square mile or 68 per cent of the mean for a period of twelve years. The run-off during the months of April, May, June, July, and August was the lowest on record while that during November, with a maximum daily discharge of 5.33 second-feet per square mile, was the highest ever recorded for this month. During November, the only month above normal, the run-off was 1.551 second-feet per square-mile, or 320 per cent of the average run-off for this month during the period of record. The minimum discharge for the year (0.036 second-foot per square mile) occurred in July and this is the lowest yet recorded.

In the eastern portion of the province the mean run-off during the year was slightly below normal as shown by the records of the typical station on the Moira river at Foxboro. The average flow for the year was 0.963 second-foot per square mile or 99 per cent of the average for the period of record. The maximum daily discharge for the year (6.00 second-feet per square mile) occurred in April and the minimum (0.056 second-foot per square mile) in August. The discharge during the months of April, May, June, and July, 1924, and February and March, 1925, was below normal. The flow during the month of May was 1.041 second-feet per square mile and was the lowest recorded to date for this month. The remaining months of the year were above normal, the discharge for November (1.753 second-feet per square mile) being 334 per cent of the mean for this month for the period of record.

In the North Bay district the mean run-off for the year was slightly below normal as shown by the records of the typical station on the South river at Powassan covering a period of twelve years. The average flow for the year was 1.3 second-feet per square mile or 93 per cent of the mean run-off of 1.4 second-feet per square mile over the period of record. The maximum daily discharge for the year (10.07 second-feet per square mile) occurred in April and the minimum (0.214 second-feet per square mile) in July. For three months only was the mean run-off in excess of the average for these months over a period of twelve years. In April the run-off was 5.034 second-feet per square mile or 105 per cent of the average for this month and in September it was 0.575 second-feet per square mile or 101 per cent of the average. During the remaining months of the year the run-off was below normal.

In the northern portion of the province the run-off for the year was slightly above the average, as shown by records of typical station on the Kapuskasing river at Kapuskasing. The average flow for the year was 0.794 second-foot per square mile or 104 per cent of the mean for the period of record. The maximum daily discharge for the year (4.624 second-feet per square mile) occurred in April. The measurements of low-flow cannot be taken as an indication of the minimum run-off from this drainage area because they are affected by the operation of a power plant above the gauging station. During the months of April, June, July, August, and December, 1925, and January and March, 1926, the discharge was above normal but this was offset by the exceptionally low run-off during the month of May, September and November so that the mean for the year was only 104 per cent of the average for the period of record as mentioned above.

SPECIAL INVESTIGATIONS

The analysis of the water power and storage resources of Ontario was continued during the year in close co-operation with the provincial authorities.

In this connection a list of water-powers in the province was issued by Mr. L. V. Rorke, Director of Surveys and Chief Engineer of the Ontario Department of Lands and Forests. In the preparation of this list and the estimation

of power at the various sites the closest co-operation and assistince of officers of the Dominion Water Power and Reclamation Service was accorded Mr. Rorke.

NIAGARA RIVER INVESTIGATION

Special study of the hydrology of the Niagara river was continued throughout the year and very satisfactory results obtained in the investigation of discharge referred to the Buffalo breakwater gauge. The studies of river slopes and the effect of diversions in governing pool levels have also been continued.

DISTRICT OF QUEBEC

L. G. Denis, District Chief Engineer

In conformity with the co-operative agreement betwen the department and the Quebec Streams Commission, basic investigatory work on water-power and allied matters was continued in Quebec province by the Dominion Water Power and Reclamation Service throughout the year. This included the operation of various hydrometric stations in different parts of the province, maintained to further the sound and intelligent development and utilization of its bountiful water-power potentialities.

ORGANIZATION

The work in Quebec is carried out under the direction of the district chief engineer's office at Montreal, close co-operation being maintained with the Quebec Streams Commission whose head office is located in the same city.

CO-OPERATION

The investigations are carried out in well defined co-operation with the Quebec Streams Commission, but, in addition to this, many private organizations interested in the data secured lend most beneficial assistance by co-operating in the various activities of the service in Quebec. Among the latter organizations may be mentioned, the Shawinigan Water and Power Company; Duke-Price Power Company; Price Brothers, Limited; Laurentide Power Company; Southern Canada Power Company; Quebec Power Company; and the Lower St. Lawrence Power Company.

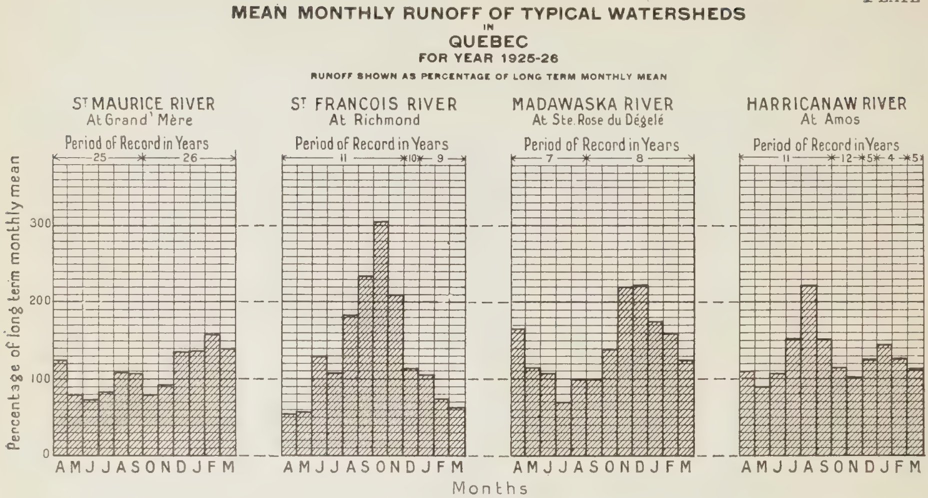
HYDROMETRIC SURVEY

There are 79 hydrometric stations of various kinds maintained in the following districts of the province; Lower Ottawa basin; Eastern Townships; North of the St. Lawrence from Montreal to below Quebec; Saguenay basin; Lower St. Lawrence. Of these stations 4 are at outlets of storage reservoirs, 4 others are operated mainly for flood observations, 10 are in co-operation with private organizations, and 24 only for gauge-height records.

Run-off conditions throughout the province during the past year were generally above normal except during the flood period, particularly on the regulated rivers where the flow was purposely kept down.

The spring of 1925 did not bring heavy floods as the weather was comparatively cool while a good portion of the snow had been disposed of through rain and mild weather during the preceding winter. The run-off during the open season following was generally above normal, rainfall for the various months, except August, being above the average. During the first half of the winter the run-off was also high owing to mild weather but later the absence of marked thaws brought a somewhat lower run-off.

PLATE 6



The above conditions are illustrated on Plate 6, showing the monthly run-off as a percentage of the average flow over a number of years at four typical stations selected in different portions of the province. These typical stations are located at Grand'mere, on the St. Maurice river; at Richmond on the St. Francois river; at Ste. Rose-du-Degele, on the Madawaska river; and at Amos, on the Harricanaw river.

In the portion of the province north of the middle St. Lawrence, the St. Maurice river, the flow of which is regulated by the Gouin and other dams, had an average run-off 96 per cent of the long-term mean at Grand'mere. The run-off per square mile at flood was 5.52 second-feet, or 52 per cent of the previous maximum recorded, and during the low winter period 0.77 second-foot, or 376 per cent of the minimum previously recorded.

In the southern portion of the province the St. Francois river, with flow regulated by the Allard dam, had an average run-off 110 per cent of the mean at Richmond. The run-off per square mile at flood was 9.09 second-feet or 50 per cent of the previous maximum and the minimum was 0.43 second-foot or 195 per cent of the minimum previously recorded.

Further east, south of the St. Lawrence, the Madawaska river at Ste. Rose-du-Degele, had an average run-off of 126 per cent of the long-term mean. The run-off per square mile at flood was 9.57 second-feet or 89 per cent of the previous maximum and the minimum was 0.31 second-foot or 600 per cent of the minimum previously estimated.

In the more northerly portion of the province the Harricanaw river at Amos had an average run-off 118 per cent of the mean. The run-off per square mile at flood was 4.07 second-feet or 62 per cent of the previous maximum, and during the low winter period 0.28 second-foot or 142 per cent of the minimum previously recorded.

SPECIAL INVESTIGATIONS

Work was continued on securing, classifying and summarizing in proper form all available data from various sources on developed and undeveloped water-power in Quebec province. These data cover particularly all surveyed or explored rivers of the province and are extensively used in satisfying numerous requests for information in connection with proposed or existing power developments and industrial expansion. Summaries for the Water-Power Resources

Inventory including power river synopses were prepared and revised, particularly for the rivers of the lake St. John basin and of the north shore of the St. Lawrence eastward to the Pentecote and Riverin rivers.

The revision of water-power tables for the whole province was also undertaken, and flow factors computed in this connection.

The water levels and flow investigation of Prairies river near Montreal was continued throughout the year.

DISTRICT OF THE MARITIME PROVINCES

K. H. Smith, District Chief Engineer

The agreement of July, 1919, between the Department of the Interior and the Governments of New Brunswick, Nova Scotia and Prince Edward Island in reference to water-power resources in the Maritime Provinces continued in force during the fiscal year ended March 31, 1926. In accordance with the terms of that agreement the power investigatory work of the Dominion Water Power and Reclamation Service was continued throughout the year.

ORGANIZATION

The District headquarters of the service is located in Halifax, where office facilities are provided by the Nova Scotia Government, adjacent to those of the Nova Scotia Power Commission.

There are two principal subdivisions of the work in this district; (*a*) Hydrometric Survey and (*b*) Special Investigations. The Hydrometric Survey consists of the systematic collection and analysis of run-off data in accordance with methods which are standard with the Dominion Water Power and Reclamation Service. The statistical data so acquired are of fundamental importance and indispensable in all problems of water supply, whether for power, industrial, or domestic uses. Under the heading "Special Investigations" is included a systematic inquiry into the water-power resources of the district by means of instrumental surveys of power and storage of all important streams, which together with the basic run-off data already referred to will produce a very complete inventory of water-power possibilities. Under this category also come all special undertakings of whatever sort made in connection with projects advanced from time to time for the more complete utilization of natural resources generally. The service is frequently called upon for information and assistance by departments of the provincial Governments, and by municipalities, corporations, and individuals; more particularly in regard to the hydro-electric development and distribution programs of the Power Commissions, in problems of town water-supply and in power development for mining, and the pulp, paper and lumber industries.

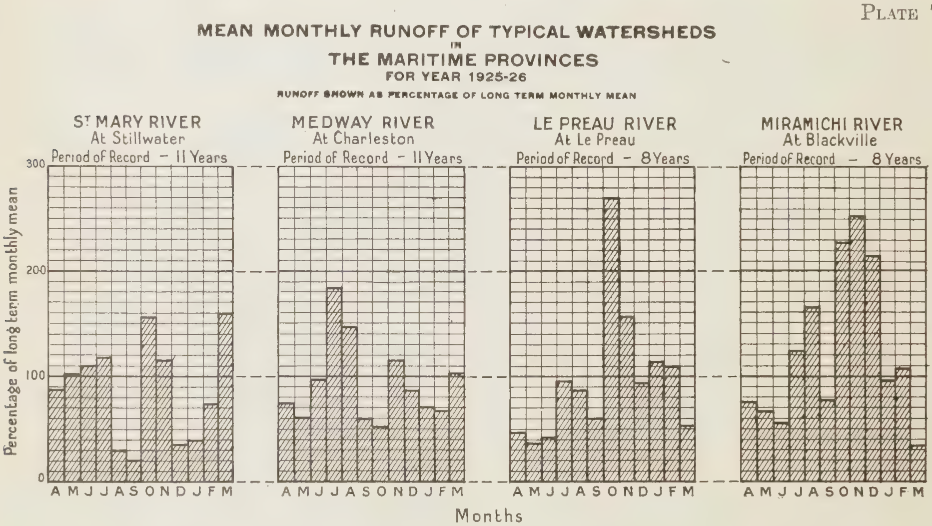
HYDROMETRIC SURVEY

During the year 35 gauging stations were maintained, 22 in Nova Scotia, 10 in New Brunswick, and 3 in Prince Edward island. Of the rivers gauged in Nova Scotia fourteen are important power streams and the remaining eight are representative, on which records are desired for statistical purposes to serve as the basis for estimates on other streams. The ten rivers in New Brunswick are, with the exception of the Kennebecasis, potential sources of power, and in addition are so distributed as to give added value to the records for comparative records of power and flow on other streams. In Prince Edward Island there are no large power sites and the three gauging stations mentioned are valuable only for statistical purposes in estimates of water supply.

Three new stations were established during the year, at Ste. Croix and East river in Nova Scotia, and the Canaan river in New Brunswick. The Ste. Croix, which is one of the most important power streams in Nova Scotia, has been actively projected for development in recent years, and reliable water supply data are therefore of importance. Due to regulation on the river and consequent interference with the natural flow, accurate records could not be secured by the usual methods; an automatic water stage recorder was, therefore, installed early in October, 1925. The East river is adjacent to the St. Margaret Bay development of the Nova Scotia Power Commission and run-off data were requested by the commission for purposes of plant operation to determine the flow into its reservoirs, so that efficient regulation could be secured. The Canaan river was brought under observation to take the place of the Kennebecasis, upon which some difficulty with unstable control has been encountered and which will, therefore, be abandoned.

The mean annual run-off for the year was below normal in all portions of the district except in northern New Brunswick. For the purpose of presenting a summary of the run-off for the year four streams have been selected as representative of conditions in their respective regions, and data pertaining to them are shown in graphical form in Plate No. 7.

PLATE 7



In eastern Nova Scotia, as typified by the St. Mary river, the average run-off for the year was 91 per cent of the mean during the years of record. Heavy rains early in April gave rise to a flow of 36 second-feet per square mile, a figure not previously reached during 10 years of record. The minimum flow of 0.08 second-foot per square mile occured in September and is double the record low flow of 1921.

The Medway river, which has been chosen to typify conditions in western Nova Scotia also experienced a subnormal average flow for the year of 86 per cent of the long-term mean. The maximum and minimum flows were 7.45 and 0.32 second-feet per square mile respectively, as compared with 14.1 second-feet and 0.07 second-foot previously recorded.

In the southern portion of New Brunswick, as exemplified by the Lepreau river, the yearly average was only 85 per cent of the mean flow for the whole period on record. Notwithstanding the low average run-off the minimum for the year of 0.31 second-foot per square mile was seven times as large as the minimum of 1921. No large floods occurred during the year. In fact, the

outstanding feature of the year from the standpoint of water supply in those portions of the district referred to above was the low spring run-off attendant upon the melting of the snow and the breaking up of the rivers in the spring. The winter of 1924-25 was mild with a comparatively light fall of snow and, generally speaking, the spring floods either failed to appear or were abnormally small.

The northern portion of New Brunswick, of which the Miramichi is characteristic, was the only section where the average run-off was above normal. A fairly generous spring run-off combined with unusually high precipitation during the fall months gave an average for the year of 117 per cent of the mean since 1918. Maximum and minimum flows of 7.60 second-feet and 0.20 second-feet per square mile respectively were recorded, whereas an average of over 50 second-feet occurred in May, 1923, followed by a minimum of 0.17 second-feet per square mile in September of the same year.

SPECIAL INVESTIGATIONS

Following the program of obtaining a complete inventory of the water-power resources of the district two power and storage investigations were completed. One of these was on the Roseway river in southwestern Nova Scotia and the other on Larry's river on the extreme eastern end of the same province. In both cases the work was carried on in considerable detail and comprised traverses over the power sections of the rivers, investigations of all storage possibilities, cross-sections at the site of proposed dams, and other data consistent with a fairly complete preliminary investigation. In the case of Larry's river, the towns of Guysborough and Canso were interested in the investigation by reason of an application to the Nova Scotia Power Commission for power supply, and the commission gave direct assistance in the field work. At the request of the Nova Scotia Power Commission and in co-operation with the engineering staff an investigation was completed of the proposed diversion from Ingram river into Ponhook lake on the St. Croix river, to augment the water supply and power available from that stream which has been under consideration for development for some time. At the further request of the Nova Scotia Power Commission a rough test was made of the new unit installed in its Mushamush plant.

For the town of Hantsport an investigation comprising considerable surveying was made of the Halfway river in connection with a proposed increase of the municipal water supply.

Disputes in regard to the use or control or water are dealt with by the provincial authorities under the Nova Scotia Water Act and frequently this service is requested to investigate and furnish data upon which adjudication may be based. During 1925-26 two such investigations were made, one on the Bear river and the other on the Medway.

An investigation was made of the power possibilities of Long Lake brook, tributary to the Herbert river, for parties interested in power supply to the gold mines near Mount Uniacke, and the project was reported upon.

A profile of the St. John river from the international boundary to Van Buren was prepared from surveys previously made by the Dominion Water Power and Reclamation Service and also certain information in regard to water levels at the International Boundary crossing of the Aroostook river was obtained in connection with hearings before the International Joint Committee.

A brief reconnaissance was made of several streams in Cape Breton in preparation for power and storage surveys which will be made as opportunity offers; several requests for information in regard to these streams have not been complied with because of insufficient data.

In New Brunswick international matters between the United States and Canadian Governments relating to the St. John and Ste. Croix rivers received considerable attention. Hearings before the International Joint Commission in reference to the proposed power development at Grand Falls were attended by the district chief engineer who also, in company with the director of this service in the latter's capacity as Canadian member of the Ste. Croix International Board of Control, made an inspection of the power reach of the Ste. Croix river forming the boundary between the two countries.

In addition to the above-mentioned investigations, many of which were made on direct request from interested parties, a great many requests for information were received from various sources which could be met by reference to filed data. These inquiries, coming as they did from widely different sources and from such varied interests such as Government departments, Canadian and foreign representatives of the mining, lumbering and pulp and paper industries, educational institutions and consulting engineers in the United States and Canada, indicate the usefulness of the investigatory and statistical work of this service.

PART II

RECLAMATION

IRRIGATION

J. S. Tempest, Commissioner of Irrigation

A summary of the reports of the various officers of the service is submitted. The original reports are on file in the offices of the Dominion Water Power and Reclamation Service at Ottawa and Calgary where further information can be obtained by those interested in any particular feature of the work.

General

The work covered by the service during the past year comprises:—

(*a*) General administration of the Irrigation Act.

(*b*) Supplying engineering assistance and advice to irrigation districts and to individual water users.

(*c*) Investigation and study of seepage and alkali problems.

(*d*) Reclassification of irrigable areas.

(*e*) Duty of water investigations.

(*f*) Study of the drought area situation in southeastern Alberta in collaboration with the provincial authorities.

Applications for the right to use water from small streams in the semi-arid districts for the irrigation of individual holdings, which increased tremendously during the past few years of subnormal rainfall, are beginning to decrease considerably owing to the scarcity of unappropriated water in many of these streams.

Numerous requests were received from the irrigation districts for assistance in locating lateral systems for individual irrigators and whenever possible these requests were complied with. The various activities in investigating soil conditions under irrigation were continued, together with the seepage studies in the larger projects. One result of the alkali investigations is the indication that alfalfa, sweet clover and sugar beets show strong alkali resistant properties. Until further research is carried out, however, it is not possible to arrive at conclusions in this respect. Damage caused to irrigable lands by seepage or by the movement of alkali has necessitated a considerable amount of reclassification of the parcels affected in the various irrigation districts. Usually the original classification has been made in the office from topography taken in the field and as in some cases small surface irregularities have developed which were not apparent on the topographical sheets—applications for adjustment have been made either by the companies, the districts or the individual water users.

For some years it has been customary to publish four graphs illustrating the relation of precipitation to wheat yield per acre. As it is considered, however, that with the increasing use of irrigation these graphs do not correctly represent the natural conditions in some of the southern districts only two graphs are now included—one representing as nearly as possible the average central Alberta conditions and the other, conditions prevailing in the semi-arid region of Alberta. Plate 8, covering the territory tributary to Edmonton, shows that the natural precipitation is normally adequate to ensure average yields. Plate 9, which covers the area tributary to Medicine Hat, indicates that in a

normal year the natural precipitation is insufficient to furnish the moisture required to produce an average crop. Both graphs cover a period exceeding forty years.

Duty of water investigations have been carried on at Brooks for the past eight years and a complete report of last year's operations and summaries of the results obtained to date are given in the tables attached.

Water Administration

During the calendar year 1925, 63 applications were filed for the use of water under the Irrigation Act. At the end of the year there were 1,277 licensed or authorized schemes, while 185 new schemes were under investigation.

One hundred and thirteen maps showing the progress of administration have now been completed to date and are available for reference purposes.

WATER SUPPLY ESTIMATES

One of the most difficult problems in administering surface water supplies is to determine the basic conditions of supply which may be expected in any particular locality. In dealing with any application or protest it is necessary to have data as to the approximate normal rate of run-off and the variation according to time. These conditions fluctuate from year to year and month to month and within comparatively short distances, depending on the elevation, topography and soil cover of the basin.

English practice is to rely very largely on records of precipitation, but this method is not so satisfactory in semi-arid regions where the absorption is very large and often out of proportion to the rainfall. At the same time, a large number of meteorological data are now available and afford a general indication of probable water supply conditions. The Meteorological Service published a comprehensive summary up to 1917 and, as opportunities occur, these tabulations are being extended from the monthly weather reports for general reference and comparison.

The practice in North America has been to obtain stream measurements extending over a period of years, but there are obviously practical and economic limits to the application of this method. The geological structure of Alberta and Saskatchewan has resulted in a number of large depressions where the run-off collects in lakes without any outlet. Since 1918, records of many lake levels have been under observation and these now cover a sufficient period to afford volumetric deductions which can be used in connection with precipitation and evaporation data to determine the approximate run-off from localities not covered by continuous stream measurements. The cost of such observations is comparatively small and is especially valuable in dealing with riparian and other problems arising from the natural and artificial control of lakes, and the effect of such control on rivers and streams of which they form a part. During the year several important cases of this kind have come up for consideration and the possession of definite information has been especially valuable.

PRECIPITATION

Crop growth is mainly dependent on the amount of moisture available during the growing season and this is roughly proportionate to the total precipitation for any crop year subject to variation in conditions for storage of soil moisture prior to the growing season.

Under average dry farming conditions it has been broadly estimated from the crop returns for twenty years at Calgary, Lethbridge and Medicine Hat that

PLATE 8

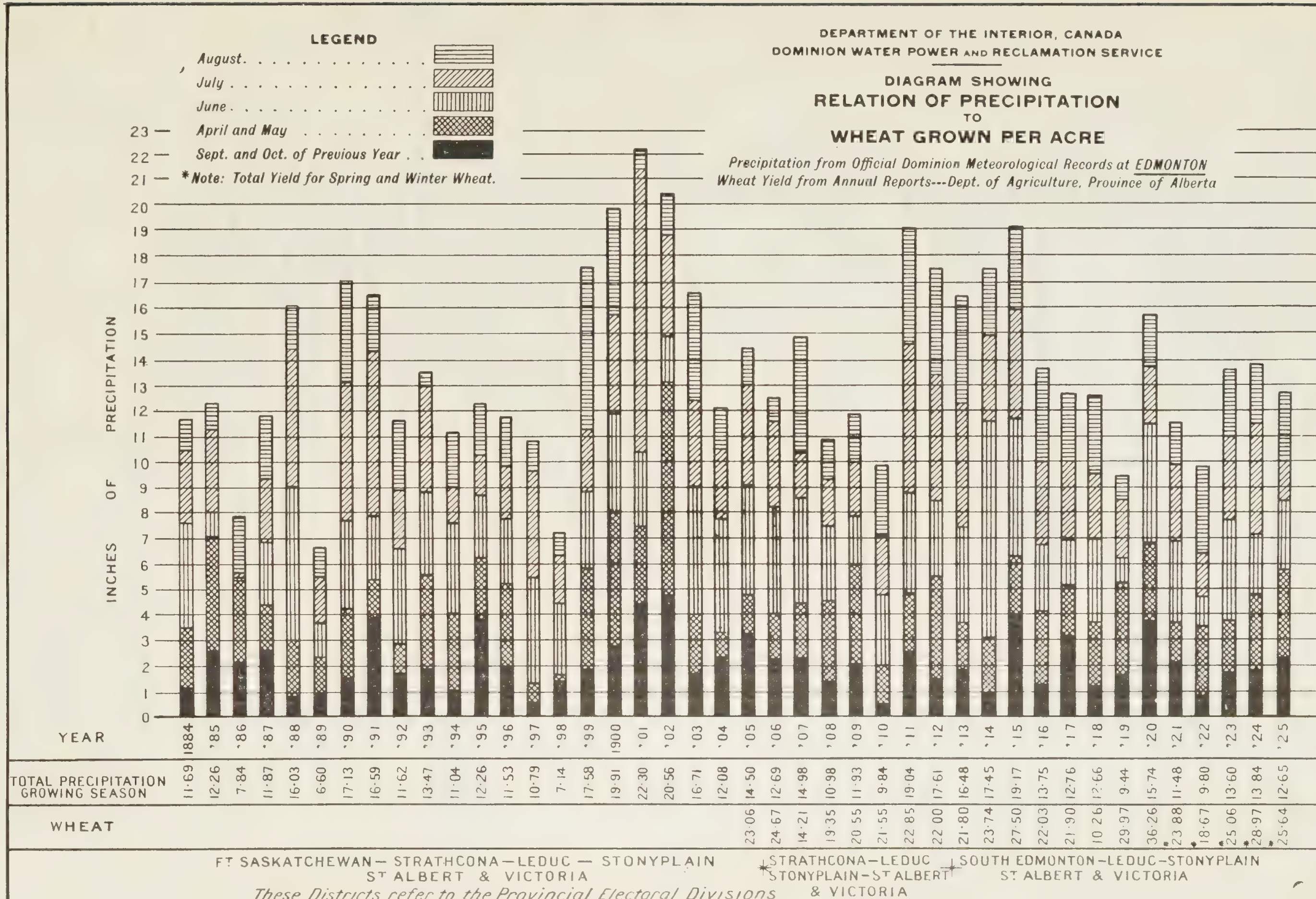
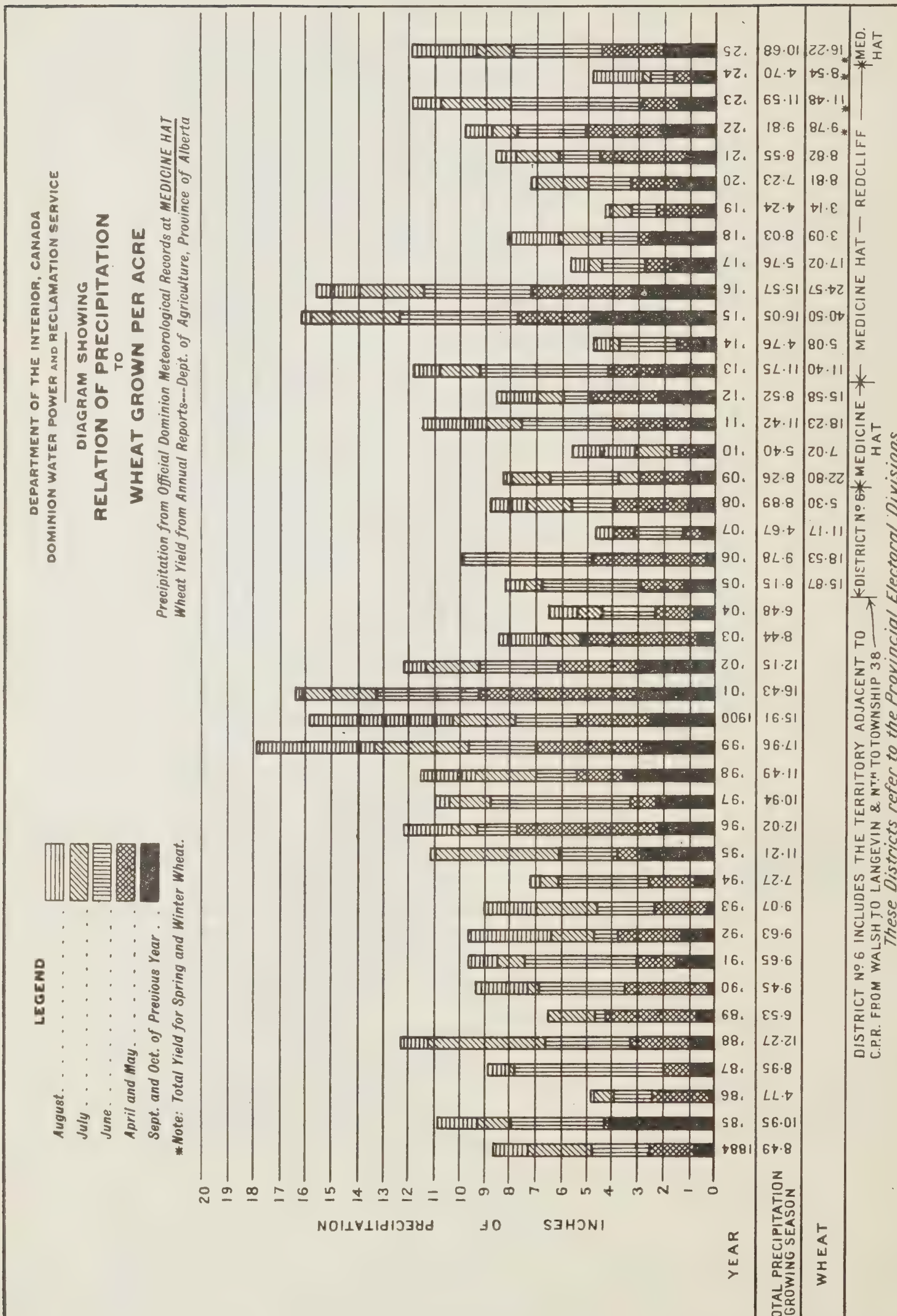

DEPARTMENT OF THE INTERIOR, CANADA
DOMINION WATER POWER AND RECLAMATION SERVICE
DIAGRAM SHOWING
RELATION OF PRECIPITATION
TO
WHEAT GROWN PER ACRE
Precipitation from Official Dominion Meteorological Records at EDMONTON
Wheat Yield from Annual Reports---Dept. of Agriculture, Province of Alberta
LEGEND
August
July
June
April and May
Sept. and Oct. of Previous Year
*Note: Total Yield for Spring and Winter Wheat.
INCHES OF PRECIPITATION
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23
YEAR
1884 '85 '86 '87 '88 '89 '90 '91 '92 '93 '94 '95 '96 '97 '98 '99 1900 '01 '02 '03 '04 '05 '06 '07 '08 '09 '10 '11 '12 '13 '14 '15 '16 '17 '18 '19 '20 '21 '22 '23 '24 '25
TOTAL PRECIPITATION GROWING SEASON
11·69 12·26 7·84 11·87 16·03 6·60 17·13 16·59 11·62 13·47 11·04 12·26 11·53 10·79 7·14 17·58 19·91 22·30 20·56 16·71 12·08 14·50 12·69 14·98 10·98 11·93 9·84 19·04 17·61 16·48 17·45 19·17 13·75 12·76 12·66 9·44 15·74 11·48 9·80 13·60 13·84 12·65
WHEAT
23·06 24·67 14·21 19·35 20·55 21·55 22·85 22·00 21·80 23·74 27·50 22·03 21·90 10·26 29·97 36·26 23·88* 18·67* 25·06* 28·97* 25·64*
FT SASKATCHEWAN — STRATHCONA — LEDUC — STONYPLAIN ST ALBERT & VICTORIA
*STRATHCONA—LEDUC STONYPLAIN—ST ALBERT & VICTORIA
†SOUTH EDMONTON—LEDUC—STONYPLAIN ST ALBERT & VICTORIA
These Districts refer to the Provincial Electoral Divisions

PLATE 9


DEPARTMENT OF THE INTERIOR, CANADA
DOMINION WATER POWER AND RECLAMATION SERVICE
DIAGRAM SHOWING
RELATION OF PRECIPITATION
TO
WHEAT GROWN PER ACRE
Precipitation from Official Dominion Meteorological Records at MEDICINE HAT
Wheat Yield from Annual Reports---Dept. of Agriculture, Province of Alberta
LEGEND
August
July
June
April and May
Sept. and Oct. of Previous Year
*Note: Total Yield for Spring and Winter Wheat.
INCHES OF PRECIPITATION
20 19 18 17 16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 0
YEAR
1884 '85 '86 '87 '88 '89 '90 '91 '92 '93 '94 '95 '96 '97 '98 '99 1900 '01 '02 '03 '04 '05 '06 '07 '08 '09 '10 '11 '12 '13 '14 '15 '16 '17 '18 '19 '20 '21 '22 '23 '24 '25
TOTAL PRECIPITATION GROWING SEASON
8.49 10.95 4.77 8.95 12.27 6.53 9.45 9.65 9.63 9.07 7.27 11.21 12.02 10.94 11.49 17.96 15.91 16.43 12.15 8.44 6.48 8.15 9.78 4.67 8.89 8.26 5.40 11.42 8.52 11.75 4.76 16.05 15.57 5.76 8.03 4.24 7.23 8.55 9.81 11.59 4.70 10.68
WHEAT
15.87 18.53 11.17 5.30 22.80 7.02 18.23 15.58 11.40 5.08 40.50 24.57 17.02 3.09 3.14 8.81 8.82 9.78* 11.48* 8.54* 16.22*
DISTRICT No. 6 INCLUDES THE TERRITORY ADJACENT TO C.P.R. FROM WALSH TO LANGEVIN & N^TH TO TOWNSHIP 38
DISTRICT No. 6
MEDICINE HAT
MEDICINE HAT — REDCLIFF
MED. HAT
These Districts refer to the Provincial Electoral Divisions

each inch of annual precipitation between six and eighteen inches represents about 2.25 bushels of wheat per acre in a crop year, thus:—

Annual Precipitation	Average Crop
8 inches	4.5 bushels
10 "	9.0 "
12 "	13.5 "
14 "	18.0 "
16 "	22.5 "
18 "	27.0 "

These figures are slightly less than those indicated by the experimental irrigation records for soil of average fertility at Brooks, where the corresponding average is about 2.7 bushels per inch, the difference being chiefly due to the greater efficiency of controlled distribution.

The precipitation in the semi-arid belt in Alberta, excluding the mountain areas, averages about 14 inches, but this comprises areas ranging from 11 to 18 inches and varies in different years from 50 to 170 or more per cent of the normal for any particular location, so that very close study of all available records is necessary in estimating the crop to be expected, apart from such conditions as soil fertility, monthly distribution, storage of soil moisture and other factors.

The normal precipitation at Medicine Hat is about 13.51 inches, but yearly records have varied from 22.08 to 6.72 inches. The general average includes three consecutive wet years of over 20 inches and since 1901 the maximum has not exceeded 17.9 inches, while the actual average for eight years ended 1910 was only 9.45 inches.

Within the semi-arid region, as a whole, it is barely one year in ten that natural precipitation can produce results approaching those obtained by irrigation, and in actual practice it has been found profitable to irrigate hay and forage crops where the normal precipitation is over twenty inches, because the yearly and seasonal variations do not always correspond with the crop requirements.

A study of long-term abnormal curves suggests definite cycles of wet and dry years, although these do not correspond exactly for different parts of the two provinces and local variations occur at comparatively short distances. Extended study of such records is, therefore, essential in order to obtain a correct historic perspective during current periods of administration.

Taking six long-term stations with records extending over forty years, it is estimated that the thirty-year period from 1888 to 1917 gives a common normal period and the stations compare as follows:—

Locality	Normal inches	Maximum		Minimum	
		Inches	Per cent	Inches	Per cent
Southern Alberta—					
Calgary	16·52	34·57	209	7·91	48
Medicine Hat	13·51	22·28	165	6·72	50
Mean	15·01	28·42	187	7·32	49
Northern Area—					
Edmonton	18·28	27·81	152	8·16	45
Prince Albert	16·18	29·88	185	7·40	46
Mean	17·23	28·84	168	7·78	46
Southern Saskatchewan—					
Swift Current	15·58	24·55	158	9·66	62
Qu'Appelle	19·47	27·19	140	10·14	52
Mean	17·52	25·87	149	9·90	57
General Means	....	....	168	....	51

The percentage variation for five periods of eight years each may be indicated as follows:—

Period	Southern Saskatchewan %	Northern Alberta and Saskatchewan %	Southern Alberta %	Mean
1885–1892	91·0	79·0	77·0	82·3
1893–1900	90·0	101·0	113·0	101·3
1901–1908	108·0	110·0	102·0	106·7
1909–1916	105·0	101·0	98·0	101·3
1917–1924	97·0	94·0	86·0	92·3
Average for 40 years	98·2	97·0	95·2	96·8
Average for 10 years. (1911–1920)	96·0	101·0	93·3	96·8

INSPECTION WORK

The process of amalgamating the duties formerly performed by the Reclamation Service and the Water Power Branch in the provinces of Alberta and Saskatchewan, was applied to the field work last season by the engineer in charge of each district assuming responsibility for the dual duties within its boundaries. For the purposes of administration the two provinces were divided into twelve districts, three in Saskatchewan and nine in Alberta, varying in size according to the amount of work in each. The names of the districts, with the number of inspections, gaugings and surveys made, and the number of regular gauging stations in each, are tabulated below.

District	Gauging Stations	Inspections	Gaugings	Surveys
South Saskatchewan	12	26	97	6
North Saskatchewan	14	7	62	1
Boundary	64	53	355	2
Medicine Hat	39	52	122	12
Calgary	18	29	156	8
Lethbridge	8	18	82	7
Vauxhall	5	2	18	1
Cardston	32	12	241	
Macleod	16	36	144	5
Banff	26	20	245	
Edmonton	13	51	71	9
North Alberta	18	44	128	10
Totals	265	352	1,721	61

Satisfactory progress has been made throughout Southern Alberta and the southwestern portion of Saskatchewan in the development of the individual gravity irrigation schemes. The many pumping projects, along the South Saskatchewan and Milk river have not yet been utilized to any great extent due to their greater construction costs. Every assistance in the way of engineering advice, locating ditches, etc., is rendered to individual applicants and they are treated with the utmost leniency by the department in extending the time for the completion of their works.

Watermasters.—The three watermaster warrants which have been in operation for several years were retained in good standing during 1925-26. These warrants grant jurisdiction over the southern portion of Alberta and the southwestern part of Saskatchewan, comprising all of the territory in which disputes

requiring adjustments in stream diversions are likely to arise. The only complaint of any importance during the season was one in connection with conditions on Battle creek and this was settled very promptly by the watermaster for that district.

Domestic Water Supplies.—Artificially formed reservoirs for domestic and stock-watering purposes are numerous in the semi-arid area of the two provinces where no perennial streams or lakes of a dependable nature are within easy reach. Usually advantage is taken of a coulee or depression in which water flows only during the spring break-up or after heavy rains, an earth dam being thrown up at the most suitable location to conserve a sufficient amount of the water available to meet the needs of the owner. Surplus water is taken care of by means of a ditch excavated around one or both ends of the dam. In addition to those in the semi-arid parts of the two provinces, there are a number in the Peace River district. The Peace river flows in a deep valley and settlers on the benches find great difficulty in obtaining water for domestic use. Wells have to be drilled to considerable depths and are very expensive, while there are few perennial streams or lakes to furnish an adequate water supply. Many applications have been received in the last few years from settlers in this district for the right to maintain dams in watercourses for domestic purposes. There are a number of unauthorized schemes of this nature and whenever they come to the attention of the department the owners are advised to protect their interests by taking the proper steps to have them legalized.

Municipal Water Consumption Data.—These data have been collected for a number of years and the records compiled therefrom are submitted in the tables appended. The department is indebted to the various towns and cities for their co-operation in furnishing this information.

Cities and Towns in the Province of Alberta—Record of Daily Water Consumption in Imperial Gallons for the Year 1925

Month	Athabaska—Population 450						Bassano—Population 1,000					
	Daily Average for the month	Per Head for domestic purposes	Per Head for industrial purposes	Per Head for other purposes	Per Head for all purposes	Unaccounted for	Daily Average for the month	Per Head for domestic purposes	Per Head for industrial purposes	Per Head for other purposes	Per Head for all purposes	Unaccounted for
January	9,082	20·2	....	....	20·2	....	190,323	....	....	....	190·3	....
February	10,491	23·3	....	....	23·3	....	196,071	....	....	....	196·1	....
March	11,329	25·2	....	....	25·2	....	164,355	....	....	....	164·4	....
April	9,562	21·2	....	....	21·2	....	150,000	....	....	....	150·0	....
May	12,500	27·8	....	....	27·8	....	160,645	....	....	....	160·6	....
June	16,823	37·4	....	....	37·4	....	158,667	....	....	....	158·7	....
July	12,796	28·4	....	....	28·4	....	214,839	....	....	....	214·8	....
August	3,024	6·7	....	....	6·7	....	223,065	....	....	....	223·1	....
September	6,000	13·3	....	....	13·3	....	201,667	....	....	....	201·7	....
October	5,645	12·5	....	....	12·5	....	171,290	....	....	....	171·3	....
November	3,083	6·9	....	....	6·9	....	157,167	....	....	....	157·2	....
December	2,984	6·6	....	....	6·6	....	148,226	....	....	....	148·2	....
Average for the year	8,610	19·1	....	....	19·1	....	178,026	....	....	....	178·0	....

Month	Medicine Hat—Population 10,000						Redcliff—Population 1,000					
January	1,761,613	....	....	....	176·2	....	123,056	....	....	....	123·0	....
February	1,708,929	....	....	....	170·9	....	95,661	....	....	....	95·7	....
March	1,660,323	....	....	....	166·0	....	94,097	....	....	....	94·1	....
April	2,185,000	....	....	....	218·5	....	92,400	....	....	....	92·4	....
May	3,085,807	....	....	....	308·6	....	183,155	....	....	....	183·2	....
June	2,889,667	....	....	....	289·0	....	199,100	....	....	....	199·1	....
July	3,785,162	....	....	....	378·5	....	302,629	....	....	....	302·6	....
August	3,516,774	....	....	....	351·7	....	185,403	....	....	....	185·4	....
September	2,552,000	....	....	....	255·2	....	158,175	....	....	....	158·2	....
October	2,265,806	....	....	....	226·6	....	112,218	....	....	....	112·2	....
November	2,419,666	....	....	....	242·0	....	88,233	....	....	....	88·2	....
December	2,445,161	....	....	....	244·5	....	87,290	....	....	....	87·3	....
Average for the year	2,522,992	....	....	....	252·3	....	143,451	....	....	....	143·4	....

Cities and Towns in the Province of Alberta—Record of Daily Water Consumption in Imperial Gallons for the Year 1925—Con.

Month	Edmonton—Population 65,000						Lethbridge—Population 13,000					
	Daily Average for the month	Per Head for domestic purposes	Per Head for industrial purposes	Per Head for other purposes	Per Head for all purposes	Unaccounted for	Daily Average for the month	Per Head for domestic purposes	Per Head for industrial purposes	Per Head for other purposes	Per Head for all purposes	Unaccounted for
January	6,152,193	54·9	23·7	16·1	94·7	....	1,323,323	68·0	33·8	....	101·8	....
February	6,244,607	55·7	24·0	16·3	96·0	....	1,170,714	54·5	35·6	....	90·1	....
March	6,262,161	55·9	24·1	16·4	96·4	....	1,119,129	55·5	30·6	....	86·1	....
April	6,294,167	55·2	24·2	16·5	96·9	....	1,220,900	54·2	39·7	....	93·9	....
May	6,144,097	54·8	23·6	16·1	94·5	....	1,572,129	82·7	38·1	0·1	120·9	....
June	6,175,333	55·1	23·7	16·2	95·0	....	1,591,267	84·2	37·5	0·7	122·4	....
July	6,488,710	57·9	25·0	17·0	99·9	....	2,120,194	147·6	9·7	5·8	163·1	....
August	6,034,19[illegible]	53·8	23·2	15·8	92·8	....	1,830,419	94·5	43·3	3·0	140·8	....
September	5,917,667	52·8	22·8	15·5	91·1	....	1,417,267	65·1	43·9	....	109·0	....
October	5,447,097	48·6	20·9	14·2	83·7	....	1,294,161	62·6	36·9	....	99·5	....
November	5,716,333	51·0	22·0	15·0	88·0	....	1,302,333	65·6	34·6	....	100·2	....
December	5,835,80[illegible]	52·1	22·4	15·3	89·8	....	1,276,226	62·1	36·1	....	98·2	....
Average for the year	6,059,364	54·1	23·3	15·8	93·2	....	1,436,505	74·7	35·0	0·8	110·5	....

Cities and Towns in the Province of Alberta—Record of Average Daily Water Consumption in Imperial Gallons for Years 1915 to 1925

Year	Per Head Domestic	Per Head Industrial	Per Head other Purposes	Per Head all Purposes	Unaccounted for	Per Head Domestic	Per Head Industrial	Per Head other Purposes	Per Head all Purposes	Unaccounted for
	Edmonton					Lethbridge				
1915	46·0	31·0	3·0	80·0	....	81·4	32·2	1·5	115·1	....
1916	52·5	20·7	5·7	78·9	....	116·0	41·3	0·7	158·0	....
1917	56·3	25·0	9·7	91·0	....	95·0	55·0	....	150·0	....
1918	58·0	26·2	10·1	94·3	....	102·2	44·7	3·0	149·9	....
1919	56·7	24·6	9·7	91·7	....	78·1	26·9	....	107·3	....
1920	54·7	23·4	16·2	94·3	....	91·8	35·1	*6·8	129·1	....
1921	54·6	23·4	16·8	94·8	....	94·2	27·8	1·4	123·4	....
1922	62·2	24·9	24·1	111·1	....	110·8	33·5	....	145·1	....
1923	53·5	22·4	13·5	89·4	....	96·0	35·4	0·7	132·1	....
1924	55·0	23·7	15·7	94·4	....	88·8	36·8	1·4	127·0	....
1925	54·1	23·3	15·8	93·2	....	74·7	35·0	0·8	110·5	....
Year	Bassano					Carmangay				
1915	6·5	60·2	....	66·7	....	41·9	....	2·0	43·9	....
1916	....	....	....	....	....	32·6	....	....	32·6	....
1917	17·9	154·3	95·4	267·6	....	31·3	....	....	31·3	....
1918	....	....	....	211·0	....	29·8	....	1·0	30·8	....
1919	....	....	....	194·7	....	32·5	....	1·2	33·7	....
1920	....	....	....	158·9	....	26·2	....	†3·4	30·3	....
1921	....	....	....	137·8	....	....	....	....	....	....
1922	....	....	....	135·7	....	....	....	....	....	....
1923	....	....	....	150·8	....		No Records			
1924	....	....	....	176·8	....	....	....	....	....	....
1925	....	....	....	178·0	....	....	....	....	....	....
Year	Medicine Hat					Redcliff				
1915	181·0	28·0	15·0	224·0	....	31·1	6·8	....	37·9	....
1916	....	....	....	214·0	....	36·8	22·1	1·0	59·9	....
1917	....	....	....	257·0	....	42·5	30·3	....	72·8	....
1918	....	....	....	264·0	....	66·4	22·4	....	88·8	....
1919	....	....	....	234·0	....	79·1	13·7	....	92·8	....
1920	....	....	....	206·8	....	67·9	16·2	....	84·2	....
1921	....	....	....	175·3	....	65·7	9·6	0·5	75·8	....
1922	....	....	....	187·9	....	97·9	7·8	....	105·6	....
1923	....	....	....	213·4	....	82·9	8·1	....	‡91·0	....
1924	....	....	....	222·2	....	136·6	8·4	....	145·0	....
1925	....	....	....	252·3	....	....	....	....	143·4	....

* 4 months. † 7 months. ‡Based on 4 months' Records.

Cities and Towns in the Province of Alberta—Record of Average Daily Water Consumption in Imperial Gallons, etc.—Con.

Year	Per Head Domestic	Per Head Industrial	Per Head other Purposes	Per Head all Purposes	Unaccounted for	Per Head Domestic	Per Head Industrial	Per Head other Purposes	Per Head all Purposes	Unaccounted for
	—					Athabaska				
1915	....	....	....	....	....	14·3	....	....	14·3	....
1916	....	....	....	....	....	10·9	....	....	10·9	....
1917	....	....	....	....	....	24·0	....	....	24·0	....
1918	....	....	....	....	....	27·6	....	....	27·6	....
1919	....	....	....	....	....	26·1	....	....	26·1	....
1920	....	....	....	....	....	44·3	....	....	44·3	....
1921	....	....	....	....	....	33·3	....	....	33·3	....
1922	....	....	....	....	....	....	....	....	27·8	....
1923	....	....	....	....	....	....	....	....	19·8	....
1924	....	....	....	....	....	18·0	....	0·2	18·2	....
1925	....	....	....	....	....	19·1	....	....	19·1	....

Cities and Towns in the Province of Saskatchewan—Record of Daily Water Consumption in Imperial Gallons for Year 1925

Month	North Battleford—Population 4,100						Kamsack—Population 375*					
	Daily Average for the month	Per Head for domestic purposes	Per Head for industrial purposes	Per Head for other purposes	Per Head for all purposes	Unaccounted for	Daily Average for the month	Per Head for domestic purposes	Per Head for industrial purposes	Per Head for other purposes	Per Head for all purposes	Unaccounted for
January	125,268	10·6	0·9	4·2	30·6	14·9	154,036	23·5	169·1	....	410·8	218·2
February	177,401	11·4	0·9	22·4	43·3	8·6	169,689	20·8	211·1	1·2	452·6	219·5
March	180,831	10·2	1·1	6·3	44·1	26·5	190,432	19·1	204·6	0·7	507·8	283·4
April	127,636	11·3	1·3	0·9	31·1	17·6	128,863	22·6	164·6	3·7	343·6	152·7
May	124,256	11·9	1·2	6·3	30·3	10·9	115,716	23·6	65·9	0·2	308·6	218·9
June	115,569	11·9	1·9	3·0	28·2	11·4	125,243	21·5	135·1	....	334·0	177·4
July	128,249	10·0	3·0	2·4	31·3	15·9	121,642	19·2	144·0	....	324·4	161·2
August	156,554	11·5	3·8	0·6	38·2	22·3	142,651	25·8	128·5	....	380·4	226·1
September	129,846	12·0	2·8	2·4	31·7	14·5	148,433	26·8	160·5	....	395·8	208·5
October	112,430	9·2	2·2	1·8	27·4	14·2	183,377	25·7	353·1	....	498·3	118·3
November	107,191	11·8	1·6	3·7	26·1	9·0	157,687	26·8	347·1	....	421·0	47·1
December	76,870	9·8	1·4	4·6	18·8	3·0	186,868	24·5	204·1	....	489·0	260·4
Average for the year	130,175	11·0	1·8	4·9	31·8	14·1	152,053	23·3	190·6	0·5	405·5	190·9

*Only 78 houses supplied or approximately 375 people. This is figure used in computations, although total population is about 2,000.

Month	Regina—Population 35,000						Saskatoon—Population 27,000†					
January	2,585,811	69·0	2·7	2·2	73·9	....	1,897,581					
February	2,590,389	69·9	2·6	1·5	74·0	....	1,863,750	28·4	17·5	1·5	70·8	23·4
March	2,661,484	68·1	6·6	1·3	76·0	....	1,966,452					
April	2,511,170	65·3	5·3	1·1	71·7	....	2,172,667					
May	2,602,087	67·7	5·3	1·3	74·3	....	2,229,516	35·5	16·7	1·4	81·3	27·7
June	2,577,427	66·7	5·6	1·3	73·6	....	2,180,167					
July	3,046,577	79·6	4·9	2·5	87·0	....	2,581,290					
August	2,951,084	77·8	4·9	1·6	84·3	....	2,372,903	30·9	22·3	6·9	88·8	28·7
September	2,812,377	75·0	4·2	1·2	80·4	....	2,232,333					
October	2,812,203	76·1	3·0	1·3	80·4	....	2,282,581					
November	2,763,522	74·3	3·2	1·4	78·9	....	2,278,667	30·9	25·5	2·3	83·4	24·7
December	2,839,019	75·8	3·7	1·6	81·1	....	2,194,194					
Average for the year	2,729,429	72·1	4·4	1·5	78·0	....	2,187,675	31·4	20·5	3·0	81·0	26·1

†Includes Town of Sutherland.

Cities and Towns in the Province of Saskatchdwan—Record of Daily Water Consumption in Imperial Gallons for the Year 1925—Con.

Month	Estevan—Population 2,500						Prince Albert—Population 7,500					
	Daily Average for the month	Per Head for domestic purposes	Per Head for industrial purposes	Per Head for other purposes	Per Head for all purposes	Unaccounted for	Daily Average for the month	Per Head for domestic purposes	Per Head for industrial purposes	Per Head for other purposes	Per Head for all purposes	Unaccounted for
January	41,226	....	....	....	16·5	....	520,155	35·2	29·9	0·4	69·4	3·9
February	39,107	....	....	....	15·6	....	494,036	28·7	26·1	0·4	65·9	10·7
March	35,355	....	....	....	14·1	....	447,000	23·4	25·2	0·9	59·6	10·1
April	32,572	....	....	....	13·0	....	522,633	35·6	21·6	1·4	69·7	11·1
May	38,323	....	....	....	15·3	....	556,452	23·7	29·5	1·4	74·2	19·6
June	46,233	....	....	....	18·5	....	596,513	30·9	38·6	1·0	79·5	9·0
July	56,968	....	....	....	22·8	....	625,590	26·8	47·4	5·9	83·4	3·3
August	49,774	....	....	....	19·9	....	531,574	28·2	31·5	1·3	70·9	9·9
September	40,700	....	....	....	16·3	....	523,217	27·3	31·7	1·0	69·8	9·8
October	38,226	....	....	....	15·3	....	474,597	28·6	27·4	0·7	63·3	6·6
November	40,400	....	....	....	16·2	....	541,750	31·5	26·0	0·7	72·2	14·0
December	44,258	....	....	....	17·7	....	513,429	30·0	27·1	0·7	68·5	10·7
Average for the year	41,928	....	....	....	16·8	....	528,912	29·2	30·2	1·3	70·6	9·9

Month	Moose Jaw—Population 21,000						Weyburn—Population 4,000					
January	889,677	34·8	8·1	....	42·9	....	231,996	....	....	....	58·0	....
February	850,821	33·4	7·1	....	40·5	....	241,987	....	....	....	60·5	....
March	837,452	32·4	7·5	....	39·9	....	230,956	....	....	....	57·7	....
April	846,367	33·8	6·5	....	40·3	....	241,937	....	....	....	60·5	....
May	921,581	34·1	9·8	....	43·9	....	272,980	....	....	....	68·2	....
June	819,133	31·1	7·9	....	39·0	....	276,604	....	....	....	69·1	....
July	976,323	32·6	13·9	....	46·5	....	283,508	....	....	....	70·9	....
August	988,258	35·3	11·8	....	47·1	....	277,288	....	....	....	69·3	....
September	953,067	30·7	14·7	....	45·4	....	259,251	....	....	....	64·8	....
October	888,645	31·1	11·2	....	42·3	....	257,218	....	....	....	64·3	....
November	893,067	34·0	8·5	....	42·5	....	257,579	....	....	....	64·4	....
December	888,290	32·3	10·0	....	42·3	....	246,085	....	....	....	61·5	....
Average for the year	896,890	33·0	9·7	....	42·7	....	256,449	....	....	....	64·1	....

—	Kindersley—Population 1,200					
January	14,903	12·4	....	....	12·4	....
February	12,589	10·5	....	....	10·5	....
March	14,129	11·8	....	....	11·8	....
April	8,700	7·3	....	....	7·3	....
May	5,177	4·3	....	....	4·3	....
June	4,400	3·7	....	....	3·7	....
July	7,500	6·2	....	....	6·2	....
August	5,903	4·9	....	....	4·9	....
September	5,750	4·8	....	....	4·8	....
October	3,823	3·2	....	....	3·2	....
November	4,650	3·9	....	....	3·9	....
December	4,935	4·1	....	....	4·1	....
Average for the year	7,705	6·4	....	....	6·4	....

Cities and Towns in the Province of Saskatchewan—Record of Average Daily Water Consumption in Imperial Gallons for Years 1915 to 1925

Average for Year	Per Head Domestic	Per Head Industrial	Per Head other Purposes	Per Head all Purposes	Unaccounted for	Per Head Domestic	Per Head Industrial	Per Head other Purposes	Per Head all Purposes	Unaccounted for
	Regina					Saskatoon				
1915	55·0	7·5	0·1	62·6	....	21·6	13·9	2·2	45·6	7·9
1916	66·1	7·8	....	68·9	....	21·0	15·4	1·9	52·6	14·3
1917	59·2	12·6	0·3	72·1	....	24·4	15·6	5·8	66·4	20·6
1918	56·9	11·1	0·1	68·1	....	27·1	17·2	2·4	63·1	16·4
1919	42·8	8·3	....	51·2	....	28·0	16·3	1·9	64·1	17·9
1920	48·9	9·1	0·9*	58·8	....	29·4	14·3	6·1	74·1	24·4
1921	49·6	10·1	2·1	62·6	0·8	29·5	20·3	1·1	72·1	21·2
1922	59·2	12·6	2·5	74·5	....	31·0	23·6	1·5	78·4	22·4
1923	61·7	14·5	2·0	78·2	....	28·8	20·8	1·5	71·0	23·1
1924	65·1	9·7	1·5	76·7	0·4	27·9	19·2	2·4	69·3	19·8
1925	72·1	4·4	1·5	78·0	....	31·4	20·5	3·0	81·0	26·1
	Weyburn					Estevan				
1915	17·4	....	0·4	17·8	....	9·5	7·1	1·5	18·1	....
1916	16·9	....	0·3	17·2	....	8·2	5·7	1·0	14·9	....
1917	30·1	....	....	30·1	....	9·7	5·5	4·3	19·5	....
1918	26·4	....	....	26·4	....	9·3	0·7	7·2	17·2	....
1919	25·5	....	....	25·5	....	9·6	2·9	....	12·5	....
1920	30·2	....	....	30·2	....	9·3	4·4	....	13·7	....
1921	27·1	....	....	27·1	....	6·1	4·7	2·0	12·8	....
1922	....	....	....	64·4	....	8·5	6·4	2·9	17·9	....
1923	....	....	....	68·0	....	8·6	10·8	1·4	20·3	....
1924	....	....	....	77·4	....	9·2	6·1	2·9	18·2	....
1925	....	....	....	64·1	....	....	....	....	16·8	....
	Moose Jaw					North Battleford				
1915	24·1	4·6	....	28·7	....	6·6	1·3	2·7	14·8	4·2
1916	35·2	12·3	....	47·5	....	9·5	2·0	4·9	22·7	6·3
1917	45·8	13·1	....	58·9	....	10·2	2·2	4·0	23·1	6·7
1918	31·6	15·4	....	47·0	....	10·0	4·8	3·0	26·3	8·5
1919	24·8	15·1	....	39·9	....	11·5	1·6	4·4	29·7	12·2
1920	24·5	14·5	....	39·1	....	11·3	5·8	5·9	34·0	10·9
1921	30·9	3·9	6·2	41·0	....	9·7	2·8	2·9	26·7	11·3
1922	34·8	9·0	....	43·8	....	11·0	2·8	4·3	34·1	15·9
1923	34·9	9·4	....	44·3	....	11·3	1·6	4·4	25·0	7·7
1924	36·5	8·0	....	44·5	....	10·8	2·3	3·7	33·4	16·6
1925	33·0	9·7	....	42·7	....	11·0	1·8	4·9	31·8	14·1
	Kamsack					Kindersley				
1915	....	....	....	....	....	4·9	8·4	1·6	14·9	....
1916	....	....	....	....	....	5·5	26·8	....	32·3	....
1917	....	....	....	....	....	5·8	44·4	....	50·2	....
1918	31·6	66·3	....	97·9	....	6·0	8·9	....	14·9	....
1919	....	....	....	....	....	7·8	....	....	7·8	....
1920	....	....	....	....	....	6·9	17·5	....	21·5	....
1921	50·4	724·9	....	775·3	....	8·5	11·0	....	19·5	....
1922	50·3	690·2	....	740·6	....	10·1	12·3	....	22·4	....
1923	27·3	291·5	58·6	478·5	101·1	11·5	....	....	11·5	....
1924	24·8	194·4	6·3	394·2	168·7	11·0	....	....	11·0	....
1925	23·3	190·6	0·5	405·5	190·9	6·4	....	....	6·4	....
	Prince Albert									
1921	....	....	....	....	....	....	....	....	83·0	....
1922	....	....	....	....	....	20·4	23·2	1·9	69·6	20·1
1923	....	....	....	....	....	22·8	27·1	1·6	70·0	18·5
1924	....	....	....	....	....	24·2	28·7	1·5	65·4	11·0
1925	....	....	....	....	....	29·2	30·2	1·3	70·6	9·9

*10 months.

Irrigation Projects

THE CANADIAN PACIFIC RAILWAY COMPANY'S PROJECTS

Western Section.—There are 218,980 irrigable acres in this section, practically all of which are under cultivation. The past operating season was the eighteenth since construction and it may now be considered that this project has passed the development stage.

During the past season 5,384 acres were irrigated, a decrease from the 1924 area of some 18,913 acres. For the irrigation of this area some 26,810 acre-feet of water were delivered, representing an average depth per irrigable acre of 4.97 feet had the water all been applied to the land. However, much of the water delivered was used for filling stockwatering ponds and a further considerable quantity was returned to the river, through the spillway channels. The number of water users was 641 as compared with 881 in 1924. The total cropped area on water right land was 209,000 acres, the principal crop being wheat, representing approximately 77 per cent of the total cropped area.

The following table shows the areas in crop on water right lands, the yields obtained, and the market price at time of harvest:—

Crop	Area in acres	Average yield per acre	Total yield	Unit value	Total value
		Bush.	Bush.	$ cts.	$
Wheat	160,000	22·50	3,600,000	1 10	3,960,000
Oats	25,000	35·00	875,000	0 30	262,500
Barley	8,000	20·00	160,000	0 35	56,000
Rye	500	20·00	10,000	0 50	5,000
Flax	500	8·00	4,000	1 75	7,000
		Tons	Tons		
Hay	4,000	1·25	5,000	10 00	50,000
Green feed	10,000	1·00	10,000	6 00	60,000
Sun-flowers	400	5·00	2,000	3 00	6,000
Corn	400	3·00	1,200	3 00	3,600
Potatoes	200	3·00	600	50 00	30,000
Totals	209,000				4,440,100

Average value per acre=$21.24.

The farmers in this section have broken up some 6,630 acres of new land in readiness for the 1926 crop season.

The average precipitation in the western section during the growing season and compared with the 1924 season is given hereunder:—

Month	Precipitation in inches		Mean average for 13 years at Strathmore	Mean temperatures in ° F.		Remarks
	1924	1925		1924	1925	
April	0·81	1·11	1·00	37·05	47·91	Precipitations for 1924–25 are averages of 8 stations scattered throughout the western section.
May	0·67	1·52	1·96	51·38	52·35	
June	4·17	4·41	2·86	54·13	55·36	
July	1·49	2·61	2·13	63·30	63·27	
August	2·31	0·84	2·09	58·00	59·65	

The period free from killing frosts covered 131 days—May 11 to September 20.

Water was turned into the system from the Bow river on April 20 and the works were closed down for the season on October 22.

Some 390,000 feet, board measure, of treated lumber were used during the season in connection with the renewals of timber structures. At the head-

works of the system a new operating pool has been constructed in connection with the sector weir. This pool is so located and constructed that water can be diverted from the flood flow of the river to fill the pool and create a head with which to operate the sector weir at low stages of the river. It has been in operation during the past season and has greatly facilitated operation during low-water periods.

The main headgates of the "B" and "C" canal systems were repaired by replacing the portions above the water line.

Eastern Section.—This project has now been in operation for 12 years. It has a total irrigable area of approximately 400,000 acres, of which some 100,170 acres have been disposed of.

A heavy winter snowfall supplied an abundance of moisture to the soil for seed germination and early spring growth. The soil moisture content was further supplemented by fairly heavy and timely precipitation during April, June and early July. Very favourable conditions for plant growth obtained during these months, temperatures being relatively high and the rainfall well distributed. Until the middle of July crops on dry land had maintained a vigorous growth. A high temperature period about the middle of July—from the 10th to 19th—seriously damaged all non-irrigated crops, but was ideal for the irrigated areas. The cool weather during the closing days of July proved very beneficial to cereal crops which were then in the dough stage. Favourable growing weather prevailed during August and the second alfalfa crop was harvested under most favourable conditions.

The period free from damaging frosts extended from May 10 to October 1. The total precipitation recorded at the Canadian Pacific Railway Company's operating headquarters at Brooks for the 12 months was 13.00 inches. The seasonal precipitation in inches as recorded at the Dominion Experiment Station at Brooks was as follows: April 1.67, May 0.46, June 2.41, July 1.86, August 0.92, or equal to 7.32 inches.

The area irrigated during the season was 72,994 acres, as compared with 84,200 acres in 1924. For this area some 130,636 acre-feet of water were delivered, representing an average depth of 1.70 feet per acre.

The number of water users was 699—a decrease of 34 from the 1924 total. The principal irrigated crop was wheat, which represented approximately 48.5 per cent of the total crop area. The following table gives the cropped area, yields received and the unit prices for the past year:—

Crop	Area in acres	Average yield per acre	Total yield	Unit value	Total value
		Bush.	Bush.	$ cts.	$
Wheat	32,320	22·90	741,945	1 33	986,787
Oats	10,686	36·10	385,912	0 34	131,210
Barley	4,361	32·10	140,245	0 46	64,513
Flax	1,350	8·60	11,608	1 95	22,635
Peas	24	12·70	304	2 00	608
Alfalfa seed	1,465	1·60	2,292	12 00	27,504
		Ton.	Ton.		
Alfalfa	12,540	1·95	24,508	10 00	245,080
Green feed	2,579	1·14	2,935	10 00	29,350
Other hay	771	0·80	716	8 00	4,936
Timothy	90	0·87	78	12 00	936
Sunflowers	26	7·30	190	8 00	1,520
Clover	70				2,844
Potatoes	60	4·71	283	40 00	11,340
Garden roots	214		847		25,200
Sugar beets	28	7·80	218	9 00	1,962
Totals	66,584				1,556,425

Average value per acre = $22.38.

Some 340,000 pounds of Grimm alfalfa seed were delivered at a co-operation cleaning warehouse yielding 257,000 pounds of clean seed. This seed had a market value of $12 per bushel.

During the past year 649 cars of live stock, valued at $800,000, were marketed from the district. This shows a wonderful advance in the live stock industry and indicates that it is now on a fairly solid footing. Prices have shown a decided improvement over last year. Poultry raising has also been an important side line on the farms as is indicated by the fact that 30,000 pounds of dressed turkeys were shipped.

The company has again expended considerable sums of money on repairs and betterments,—the largest item being in connection with the drainage of surplus surface waters and the creation of adequate spillway channels. In the St. Julien colony considerable improvement work was carried out on ten of the farms, this work consisting of land levelling, drainage and the construction of fills on head ditches at points where such was considered too costly for the farmer to undertake. Improvements have been made in all divisions of the project in connection with surface drainage conditions and 18.5 miles of new drainage channels have been constructed with 31 new timber structures.

An aquatic weed growth in the Bantry system again caused the company considerable trouble and expense. In order to maintain the water supply and to safeguard the canals against damage from overtopping their banks at full supply level, it was necessary to remove this growth. The method employed consisted of dragging heavy anchor chains through the canals and removing the growth at convenient points. The company has obtained expert advice in connection with this problem and it is probable that further experiments to combat the nuisance will be made during the coming season.

An active, organized campaign has been carried on during the past summer with a view to checking the damage which is being caused by the spreading of noxious weeds through many of the districts. Most damage is being caused by the perennial sow thistle, but Canada thistle and the wild oat are also becoming a serious menace.

The company has made a special study of all occupied farm units upon which alkali has made an appearance with a view to ascertaining the cause and establishing remedial measures.

Lethbridge Section.—The source of supply for this project is the St. Mary river, the headworks being located in section 36, township 1, range 25, west of the 4th meridian. At the close of 1925, there were 74,571 acres under water agreement. The area which actually received water was 81,110 acres and included leased and rented lands not at present under water agreement.

The average per acre value of the crops raised on the irrigated lands during the season was $35.73 as compared with $26.53 in 1924 and $18.81 in 1923. On the non-irrigated lands, the average per acre value of the crops raised in the district was $18.41 as compared with $20.78 in 1924. A table of areas cropped with yields and values is appended.

Crop	Area in acres	Average yield per acre	Total yield	Unit value	Total value
		Tons	Tons	$ cts.	$
Alfalfa	12,767	2·18	27,833	13 00	361,829
New alfalfa	488	0·91	443	13 00	5,759
Timothy	5,175	1·16	5,998	17 00	101,966
Alfalfa and timothy	520	1·76	917	14 00	12,838
Green feed	1,988	1·80	3,587	13 00	46,631
Other hay	2,810	1·82	5,129	15 00	76,935
		Bush.	Bush.		
Wheat	21,589	25·18	543,625	1 25	679,531
Oats	4,953	41·06	203,377	0 45	91,520
Barley	2,410	28·48	68,643	0 65	44,618
Fall rye	158	11·03	1,740	0 90	1,566
Flax	433	19·93	8,631	2 00	17,262
		Tons	Tons		
Sunflowers	47	10·74	505	5 00	2,525
Corn	262	8·48	2,222	6 00	13,332
		Bush.	Bush.		
Peas	2	30·00	60	3 00	180
		Tons	Tons		
Potatoes	959	5·23	5,010	40 00	200,400
Sugar beets	3,088	10·99	33,946	7 50	254,595
Other roots	76	9·95	754	8 00	6,032
Garden truck	363	7·25	2,637	60 00	158,220
Total	58,088	....	....	....	2,075,739

Average value per acre=$35.73.

Water was turned into the system on May 4 and operation was continuous until October 15. There were 803 actual water users. Speaking generally, the conditions throughout the district in the spring were very favourable, with moisture in the soil for seed germination. Although May was a dry month, the June precipitation was sufficient to maintain an excellent growth. July was dry and irrigation soon became necessary to maintain growth and ensure the crop. There was evidence during the past season that many of the farmers did not delay their irrigations until irreparable damage had been caused as has often unfortunately been the case. During the growing season, or from May 1 to August 31, 6.50 inches of rainfall were received in the vicinity of Lethbridge. September and October were exceptionally unfavourable months with early snowfalls and low temperatures. The precipitation for September recorded at Lethbridge being 4.86 inches and 1.08 inches in October.

A notable event in this district during the past year has been the creation of the sugar beet industry. A modern factory with a maximum daily grinding capacity of 1,000 tons of beets was erected at Raymond during the summer months and opened for operation on October 19. In order to ensure production of sufficient beets to warrant establishing the factory, an active campaign was undertaken during the fall of 1924 and spring of 1925. From the crop report, it will be noted that some 3,088 acres in this district were, as a result, devoted to sugar beets, producing an average yield of 10.99 tons per acre at $7.50 per ton. Unfavourable weather was experienced during the ripening period, August and September being wetter and colder than normal, which greatly retarded ripening, and in consequence, reduced the sugar content. Beet harvesting commenced in the Raymond district during the last week of September, the first carload being delivered at the factory on October 9. The October storms made harvesting very unpleasant work and in consequence suitable labour was difficult to retain. While the 1925 costs for harvesting greatly exceeded the estimate, future average costs should be much lower.

TABER IRRIGATION DISTRICT

This district is supplied with water from the St. Mary river through the works of the Canadian Pacific Railway Company's Lethbridge section. The 1925 operating season was the fifth since construction. The present classified

irrigable area is 17,249 acres, which is subject to adjustment from time to time as conditions may require. The bonded indebtedness at the close of the year was $272,000 and the total cost of construction $274,339. There are 144 water users in the district and some 13,472 acres were irrigated, which represents 79 per cent of the irrigable area. The total per acre assessment for the past season was $1.50 of which 96 cents was for interest and sinking fund, and 54 cents on account of operation and maintenance.

Water was turned into the system on May 27 and operation was continuous and at almost full capacity until the end of July. The headgates were closed for the season on October 27, in so far as irrigation requirements were concerned. The stormy weather which commenced on September 5 reduced demands to a minimum and water requirements after this period were chiefly for filling stock watering ponds. In consequence of this demand the headgates were opened at intervals until November 21, when they were finally closed for the year. The total quantity diverted during the period of operation was 22,856 acre-feet. A study of the monthly diversion quantities brings out very clearly the periods of maximum requirement. Of the 22,856 acre-feet diverted into the system 4.5 per cent was used in May, 32.5 per cent in June, 34.1 per cent in July, 16.1 per cent in August, 7.8 per cent in September, and the remainder, or 5 per cent in October and November. Of the 13,472 acres irrigated, only 235 represent fall irrigation.

The past season was below the average with respect to useful precipitation. During the important period from April to September only 8.54 inches were received, made up as follows:—April 1.83, May 0.14, June 1.38, July 0.93, August 0.96 and September 3.30.

The crop returns are encouraging and show a satisfactory increase over 1924. During the past year sugar beets were grown on a commercial scale in this district, the total acreage devoted to beets being 752. The average yield obtained was 6.5 tons per acre and the price per ton, delivered at the factory was $7.50. The season, unfortunately, was a most unfavourable one for the growing of sugar beets—conditions being too dry at time of seeding and too wet and cold during the ripening and harvest periods. Wheat was again the major crop of the district, 8,245 acres being seeded to spring wheat yielding 162,064 bushels, or an average of 19.6 bushels per acre. Greater attention is now being given to the preparation of land for receiving water and the farmers of this district are undoubtedly more keenly alive to the value of the water and the necessity for its proper application than they have ever been before. A summary of the cropped area, the yields received, and unit prices at harvest is given hereunder.

Crop	Area in acres	Average yield per acre	Total yield	Unit value	Total value
		Tons	Tons	$ cts.	$
Alfalfa	1,619	2·3	3,740	13 00	48,620
		Bush.	Bush.		
Alfalfa seed	55	1·8	97	18 00	1,740
		Tons	Tons		
Timothy	206	1·3	275	17 00	4,675
Green feed	491	1·1	544	13 00	7,072
Oat hay	131	0·9	115	15 00	1,725
		Bush.	Bush.		
Wheat	8,245	19·6	162,064	1 25	202,580
Oats	1,433	33·0	47,286	0 45	21,278
Barley	657	23·7	15,564	0 65	10,117
Flax	117	14·1	1,650	2 00	3,300
		Tons	Tons		
Sugar beets	752	6·5	4,943	7 50	37,072
Potatoes	101	3·3	334	40 00	13,360
Totals	13,807				351,540

Average value per acre=$25.46.

Considerable maintenance work was undertaken, particularly in the eastern end of the district. Several miles of distributary ditches were cleared of silt, levees raised and repaired and all structures riprapped on the downstream side. Due to stock watering at canals on road allowance crossings, considerable damage has resulted to the banks on either side of the bridges and culverts. Many of these have now been riprapped and the result has been very satisfactory. Some extra work was caused in the spring as a result of the washing out of some sixty small "drops." It is thought this was caused in some cases by burrowing animals and in others by the cracking and opening up of the ground due to alternate freezing and thawing. Some sub-surface draining has been undertaken by the district on one of the water users farms, with a view to relieving seepage from one of the levees of the main canal system. Four-inch tile drains were used and results will be carefully watched during the coming season.

The number of live stock in the district has shown a considerable increase over the 1924 season, in so far as beef cattle and sheep are concerned. Sheep have increased from 817 in 1924, to 2,263. Hog raising, however, shows a slight decline when compared with 1924 figures.

At the request of the district, investigations have been made of certain areas damaged by seepage and of other areas where unsuitability of surface or sub-surface conditions have been reported. In most cases adjustments in classification were effected and the irrigable areas reduced accordingly.

BOW RIVER PROJECT OF CANADA LAND AND IRRIGATION COMPANY, LIMITED

This project diverts its water from the Bow river in section 31, township 21, range 25, west of the 4th meridian. There are some 530,250 acres of land originally acquired by the Company of which approximately 202,640 are irrigable.

In the early part of 1925 the receiver for the project entered into an agreement with the Minister of the Interior whereby the Minister was to act as agent for the receiver and to arrange for the finances to carry on the construction, operation, maintenance and settlement of the project, the cost of such operations, in excess of revenue, to be secured as a charge against the company's assets. This arrangement became effective April 16, 1925, and funds to the amount of $50,000 were advanced for the purposes above stated.

In respect of construction, an extension was made to Drop No. 3 on Division "A," and a patrol house built to accommodate a ditch rider for the western district of the project. Ten bridges were rebuilt and sundry repairs made to other structures on the main canal. One new ditch was excavated in the western district and a number of drops placed in ditches which had previously been in use.

Very satisfactory results were obtained on the irrigated lands of the project. The total cropped area for the year was 10,280 acres; returns from which, at a conservative unit value of yield, amounted to $360,169, or an average of $35.03 per acre. Market values were generally good and the actual returns were probably in excess of the average given above.

A summary of the cropped areas, yields and values for the past season are given in the table hereunder:

Crop	Area in acres	Average yield per acre	Total yield	Unit value	Total value
				$ cts.	$
Alfalfa	1,762	2·69 tons	4,746 tons	13 00	61,698
Alfalfa seed	55	3·80 bush.	209 bush.	12 00	2,514
Barley	836	40·85 bush.	34,140 bush.	0 65	22,191
Sugar beets	6	14·06 tons	90 tons	7 50	675
Corn (silage)	28	11·07 tons	310 tons.	6 00	1,860
Corn (pasture)	12	....	....	50 00	595
Flax	52	12·64 bush.	660 bush.	2 00	1,320
Garden	52	....	....	....	15,510
Hay	35	1·00 tons	36 tons	15 00	540
Oats	1,217	56·75 bush.	69,062 bush.	0 45	31,078
Oats (green feed)	132	1·50 tons	198 tons	13 00	2,574
Pasture	385	....	....	....	7,695
Potatoes	69	8·93 tons	620 tons	40 00	24,800
Wheat	5,639	26·54 bush.	149,695 bus.	1 25	187,119
Totals	10,280	....	....	....	360,169

Average value per acre=$35.03.

NEW WEST IRRIGATION DISTRICT

The water supply of this district is obtained from the Bow river through the works of the Canada Land and Irrigation Company. The district's headgates are located in the NE.¼ section 26, township 13, range 17, west of the fourth meridian. The district contains an irrigable area of 4,501 acres and is operated by a manager who carries out the duties of water master and ditch rider. The area irrigated in 1925 was 3,552 acres, or 78.9 per cent of the irrigable area, as compared with 37 per cent in 1924. The number of water users in 1925 was 26, an increase of 9 over the previous year.

The average per acre yield of wheat in 1925 was 20.6 bushels as compared with 5 to 10 bushel yields on adjoining dry lands. The district's yield, however, would undoubtedly have been higher had it not been for a general tardiness on the part of the farmers towards irrigating sufficiently early in the growing season. With the moisture carried over from the previous fall and several showers during the first two weeks of June, the crops made an excellent start and progressed rapidly. In July, however, conditions changed and with no reserve moisture in the soil, a few hot days caused damage which delayed irrigations could not remedy. The rainfall in inches recorded at Vauxhall, the nearest meteorological station, during the growing season was as follows:—April 1.69, May 0.40, June 2.11, July 0.97, August 1.33, equal to 6.50 inches. There was no damage caused either from hail or pest during the season. A summary of the crops, the yields obtained and the market price at time of harvest, is given hereunder:—

Crop	Area in acres	Average yield per acre	Total yield	Unit value	Total value
		Tons	Tons	$ cts.	$
Alfalfa	4	2·5	10	13 00	130
Green feed	365	1·5	548	13 00	7,125
		Bush.	Bush.		
Wheat	2,214	20·6	45,600	1 25	57,000
Oats	309	38·1	11,761	0 45	5,292
Barley	125	36·6	4,575	0 65	2,974
Flax	40	9·3	370	2 00	740
Totals	3,057	....	....	....	73,261

Average value per acre=$23.97.

LETHBRIDGE NORTHERN IRRIGATION DISTRICT

There are 104,438 acres in this project classified as irrigable, of which 43,628 acres were irrigated during the past season. The 1925 season was the second year of operation and crop returns indicate considerable progress. The burden of excessive individual holdings has been greatly relieved by the passing by the provincial Government of "The Lethbrige Northern Colonization Act," which was assented to on April 10, 1925. This Act was framed after a most careful and exhaustive survey of the whole project by Dr. J. A. Widtsoe, an outstanding authority on irrigation methods in the United States, who undertook the work for the provincial Government during the winter of 1924-25. The Act has three fundamental principles: (1) "Home place" registration, i.e. establishing individual farms in units of a size most adapted to irrigation practice. (2) Colonization of surplus and vacant lands in excess of "home place" units. (3) The production of crops.

Under the provisions of this Act, bona fide resident water users had the privilege of registering a "home place." Upon such lands being accepted by the colonization manager and registered as a "home place" irrigation rates were payable on a reduced scale, increasing with productive efficiency. Under section 22 of the Colonization Act, the provincial Treasurer is empowered to advance to the Board of Trustees out of the general revenue fund of the province, any sum or sums required to make up the difference between the irrigation rates imposed upon the "home places" under the provisions of the Irrigation Districts Act, and also the payments in respect of "home places" under the provisions of the Colonization Act and the irrigation rates due upon all lands vested in the manager. In addition to this helpful legislation, provision has also been made for loans to approved water users for the purchase of building material and live stock.

During the past year 377 "home place" farm units, aggregating a total irrigable area of 53,262 acres, were registered, representing an average irrigable area per unit of 141 acres. In addition the Colonization Department has established 138 new families on 14,537 irrigable acres or an average of 105 irrigable acres per farm unit. The financial condition of this district at the end of 1925 shows some improvement over the previous year, but a considerable amount of bonded indebtedness must continue to be borne.

In response to an urgent appeal from the district for engineering assistance in laying out farm laterals, arrangements were made for seven of our engineers to give some of their time to this work. During the months of May and June, 125 farms were visited and the necessary head ditches located. In every case the farmers were on hand with plough and team to follow up the located line. The total acreage surveyed with farm ditches amounted to 6,600. In order that the farmers might receive the fullest benefit from the facilities created by the construction of the farm ditches, our senior irrigation specialist visited many of the farms during July and gave further advice as to when and how to apply the water.

During the year some 130,019 acre-feet of water have been diverted from the Oldman river, a proportion of which has been stored in Keho Lake reservoir. Water was turned into the system on April 27 and the headgates were closed on October 17. The highest daily discharge recorded was 571 cubic-feet per second on July 12, the average flow for July being 485 cubic-feet per second.

Special studies are being made of the water losses in the upper portion of the main canal and also of Keho Lake reservoir, but further investigations will be necessary before any conclusions can be arrived at.

A very careful crop census has been made by the district's officials and the figures obtained show substantial increases in both yields and values. The table appended gives a summary of the crop yields and unit values at harvest.

Crop	Area in acres	Average yield per acre	Total yield	Unit value	Total value
				$ cts.	$
Alfalfa	560	2·50 tons	1,431 tons	13 00	18,610
Barley	1,019	25·00 bush.	25,543 bush	0 65	16,603
Flax	341	10·40 bush.	3,552 bush	2 00	7,104
Oats	3,499	39·40 bush.	137,782 bush	0 45	62,002
Green feed	2,971	1·70 tons	5,083 tons	13 00	66,085
Other hay	538	1·10 tons	597 tons	15 00	8,962
Potatoes	95	4·70 tons	451 tons	40 00	18,028
Corn	82	2·03 bush.	168 bush	6 00	1,008
Sugar beets	242	4·20 tons	1,021 tons	7 50	7,661
Wheat	27,493	23·36 bush.	642,245 bush	1 25	802,806
Timothy	104	1·90 tons	204 tons	17 00	3,468
Totals	36,944				1,012,337

Average value per acre = $27.40.

The sum of $51,341.31 was expended on maintenance and operation during the past season.

The precipitation in the Lethbridge district was well above the average of the past 24 years. During the months of May, June and July, however, the amount received was considerably below the average and irrigation was necessary to ensure crops. The records at Lethbridge, Macleod, Kipp and Noblefield are given hereunder, together with the average at Lethbridge for the past twenty-four years.

Rainfall Records, 1925

Month	Lethbridge	Lethbridge average twenty-four years	Macleod	Kipp	Noblefield
January	0·30	0·66	0·60	0·50	0·42
February	0·99	0·65	0·50	0·80	0·63
March	2·26	0·74	2·40	1·70	2·20
April	1·99	0·95	1·21	1·82	1·58
May	0·43	2·46	1·01	0·87	0·97
June	3·40	2·74	3·12	3·53	5·96
July	0·82	1·84	0·42	0·43	1·22
August	1·85	1·74	1·36	2·50	2·53
September	4·86	1·64	3·00	5·25	3·47
October	1·08	0·86	0·60	1·48	1·55
November	0·16	0·59	nil	0·20	0·15
December	0·62	0·62	0·60	0·40	0·46
	18·76	15·49	14·82	19·48	21·19

The temperatures at Lethbridge during the growing season are given hereunder:—

Month	Maximum	Minimum	Mean
April	78° (10th)	19° (28th)	43·8°
May	83·5° (20th)	12° (10th)	52·6° Last spring frost May 11.
June	92° (29th)	33° (1st)	59·8°
July	92° (11th)	43° (8th)	64·7°
August	90·5° (3rd)	38° (29th)	61·5°
September	85° (1st)	25° (20th)	50·1° first frost September 20.

UNITED IRRIGATION DISTRICT

There are some 36,158 irrigable acres in the district, of which 27,118 were irrigated during the past season, as compared with 10,444 in 1924.

Water was turned into the system on May 1 and ran continuously until September 29. The works were again operated from October 19 to 26 for the purpose of filling farmers' reservoirs. A total of 25,671 acre-feet of water was diverted from the Belly river during the season.

The precipitation as recorded at Hillspring during the growing season was 11.25 inches, made up as follows: April, 1.47; May, 0.83; June, 2.88; July, 0.97; August, 2.14; September, 2.96. The June rains were distributed fairly evenly throughout the month although only 2.80 inches was recorded. Early in July a heavy demand for water started and continued throughout the month. Generally speaking, very few of the farmers had made the necessary preparation to receive the water and in consequence its application was not very satisfactory and the most beneficial results were not obtained. The services of a provincial government engineer for locating farm lateral ditches were obtained during part of the season, but he was only able to undertake a very small portion of the work required. The assistance given, however, clearly demonstrated the value of this service, as it enabled farmers whose lands were surveyed and ditched to proceed with their water distribution. The month of July was hot and accompanied by drying winds with less than one inch of rainfall. Had water been more generally applied during June and July the yields throughout the district would have been very greatly increased.

A summary of the crops grown on the irrigated lands together with their average yield and value is given in the following table:—

Crop	Area in acres	Average yield per acre	Total yield	Unit value	Total value
		Tons	Tons	$ cts.	$
Alfalfa	288	2·5	720	15 00	10,800
		Bush.	Bush.		
Barley	600	20·0	12,000	0 60	7,200
Flax	200	8·0	1,600	1 50	2,400
Oats	1,500	40·0	60,000	0 50	30,000
		Tons	Tons		
Green feed	2,000	1·5	3,000	12 00	36,000
Hay	200	1·0	200	12 00	2,400
Potatoes	100	5·0	500	25 00	12,500
		Bush.	Bush.		
Wheat	39,282	15·0	589,230	1 16	684,153
Totals	44,170				785,453

Average value per acre = $17.78.

A few new settlers have moved into the district and have acquired or rented lands from those with large individual holdings. Three of these came from Utah, U.S.A., and the remainder from southeastern Alberta. This district could absorb a considerable number of experienced farmers, as the average holding of irrigable land is greater than can be economically farmed as one unit.

A complete reclassification of the 337 quarter-sections contained in this district has now been made and the amended areas, together with the revised plans, will be submitted to the district in the near future.

Some expenditure was necessary at the beginning of the season for the removal of drift from the lateral canals. A few new structures have been built on the lateral canals, including two bridges, two checks and one combination headgate and check. In order to facilitate the disposal of surplus surface water a chute some 240 feet in length has been constructed from the end of lateral F-7, through which water is returned to the Waterton river.

The system is operated by a manager and four ditch riders. Further temporary assistance is engaged from time to time as repairs to canals or structures become necessary.

The assessment rate for 1924 was $1.25 per irrigable acre. For 1925 the rate was increased to $1.35, which would yield some $48,600 from the whole project. Of this revenue, 87 cents per acre goes toward meeting interest on debentures and 48 cents for operation of the system and sinking fund.

LITTLE BOW IRRIGATION DISTRICT

This project diverts its water from the Highwood river in N.E. ¼ sec. 1, tp. 19, rge. 29, W. 4th meridian, near the town of High River. The water is passed through a small section of constructed canal into the channel of the Little Bow river. During the year water was diverted for domestic purposes only, as the pumping plants for the individual schemes along the Little Bow river have not yet been constructed.

Summary of 1925 Crop Reports From the Following Districts

District	Irrigable Area	Irrigated 1925	Acres Cropped
Canadian Pacific Railway Western Section	218,980	5,384	209,000
" " Eastern Section	400,000	72,994	66,584
" " Lethbridge Section	130,000	81,110	58,088
Taber Irrigation District	17,249	13,472	13,807
Canada Land and Irrigation Co	202,640	10,174	10,280
New West Irrigation District	4,501	3,552	3,056
Lethbridge Northern Irrigation District	104,438	43,628	36,944
United Irrigation District	36,158	27,118	44,170
Totals	1,113,966	257,432	441,929

Crop	Acreage	Average Yield per Acre	Total Yield	Average Unit Value at Harvest	Total Value	Per Acre Value
		Bush.	Bush.	$ cts.	$	$ cts.
Wheat	296,783	21·8	6,474,404	1 17	7,559,976	25 47
Oats	48,597	36·8	1,790,180	0 35	634,881	13 06
Barley	18,008	25·6	460,710	0 49	224,216	12 45
Rye	658	17·8	11,740	0 56	6,566	9 98
Flax	3,033	10·6	32,071	1 92	61,761	20 56
Peas	26	14·0	364	2 17	788	30 31
		Tons	Tons			
Alfalfa	29,540	2·1	62,988	11 85	746,766	25 27
" (new)	488	0·9	443	13 00	5,759	11 80
		Bush.	Bush.			
" (seed)	1,575	1·7	2,618	12 13	31,758	20 16
		Tons	Tons			
Timothy	5,575	1·2	6,555	16 94	111,045	19 92
" and alfalfa	520	1·8	917	14 00	12,838	24 64
Green feed	20,526	1·3	25,895	9 84	254,837	12 41
Oat hay	131	0·9	115	15 00	1,725	13 17
Other hay	8,353	1·4	11,579	12 42	143,774	17 21
Sunflowers	473	5·7	2,695	3 73	10,045	21 24
Corn	784	5·0	3,912	5 21	20,395	26 01
Potatoes	1,584	4·9	7,798	39 81	310,428	195 98
Sugar beets	4,115	9·8	40,218	7 51	301,965	73 38
Other roots	76	9·9	754	8 00	6,032	79 37
Garden truck	629	6·0	3,784	52 57	198,930	316 26
Clover	70				2,844	40 63
Pasture	385				7,695	20 00
Totals	441,929				10,655,024	24 11

N.B.—Canadian Pacific Railway (Western) Reports cover water right lands whether irrigated or not.

Canadian Pacific Railway (Western) Alfalfa and all hay crops under heading "other hay".

MOUNTAIN VIEW

Although authorization for the construction of the works of this district was issued on June 23, 1925, very little progress was made during the year. Adverse weather conditions during the fall made it impossible for the farmers to complete any large amount of the excavation work.

It will be necessary before certain structures are built for the district to file detail plans with the department. The district has promised to employ an engineer before undertaking the construction of any structures and it is expected that suitable plans will be prepared at this time.

MAGRATH

Considerable progress has been made during the year by this district. Detailed plans and cost estimates which were prepared by the district's engineer have been submitted for the consideration of the management of the Canadian Pacific Railway Company who are entering into a contract with the board of trustees for the construction of the necessary works, and for the supply of water required for the included lands.

The district has petitioned the Minister of Railways and Telephones of the province for the exclusion of certain lands and the inclusion of others. Since this change will not affect the feasibility of the scheme, the department has approved of the scheme as now outlined.

RAYMOND

The order forming this district was published in the Alberta *Gazette* dated March 31, 1925, and considerable progress has been made during the year. In the case of this district no new works are required but the Canadian Pacific Railway Company are entering into a contract with the district trustees for the maintenance and repair of certain works and for a supply of water required.

Test Plots

ALKALI TEST PLOTS AT MAPLE CREEK, SASKATCHEWAN

These plots, which were instituted primarily for the purpose of ascertaining the effect of irrigating heavy creek flat lands of high alkali content, have now been operated for the past four years. It is the intention to carry out these operations for a period of ten years and it is hoped to prepare a complete report of the first five years' operations during the winter of 1926-27. The secondary purpose of these experiments is to ascertain the effect of these particular conditions on certain crops. The results of the experiments when finally obtained will be applicable to large areas of potentially irrigable lands in different parts of the country. No free alkali has as yet appeared on the surface of any of the plots nor does the alkali appear to affect the crops although tests indicate that it is very near the surface. It is, however, premature, on the data so far obtained, to base any positive statements.

Brooks Irrigation Experiment Station

CLIMATOLOGY

Climatic conditions during the first four months of the season were particularly favourable for plant growth, and though adverse weather conditions obtained during September and October, a bountiful crop was harvested.

The main features of the weather were (1) a heavy winter snowfall which ensured an abundance of moisture to the soil for early spring plant growth and

germination of early seed crops; (2) relatively high temperatures, particularly during the earlier periods of growth; (3) a relatively high effective rainfall during the growing season, together with low evaporation and (4) an unusually heavy precipitation during September followed by low temperature periods and low relative humidity during October.

The last spring frost occurred June 6, while the first fall frost occurred September 20. In each case, however, only light frosts were recorded and no perceptible damage was done. The period free from killing frost extended from May 10 to October 1, when the temperatures recorded were 22 degrees F. and 18 degrees F., respectively.

A summary of temperature, precipitation, evaporation, relative humidity and wind records is shown in the table below. Deviations are indicated excepting in cases where records have not been taken for a sufficient length of time to establish a dependable average.

Summary of Meteorological Data, Brooks, 1925

Month	Temperature Records						Evaporation		Precipitation			Wind	
	Maximum rec'd	Minimum rec'd	Average Maximum	Average Minimum	Mean	Departure of Mean from average 1915-24	Total inches	Departure from average 1918–24	Total inches	Departure from average 1918–24	Relative humidity	Average hourly velocity	Maximum velocity recorded
	°F.	°F.	°F.	°F.	°F.	°F.		inches		inches	p.c.		
April	78	22	59·0	32·8	45·9	+3·87	2·50	−0·53	1·67	+0·75	58	8·96	31
May	87	22	70·3	37·6	54·0	+2·74	4·42	−1·12	0·46	−0·54	58	6·30	37
June	94	32	74·7	46·8	60·7	+0·10	3·95	−1·70	2·41	+0·50	80	3·07	......
July	93	44	81·6	51·1	66·4	−0·5	4·39	−1·99	1·86	+0·42	72	2·39	......
August	94	36	80·6	46·6	63·6	−0·7	3·67	−0·25	0·92	−0·80	65	3·18	15
September	87	30	66·3	39·7	53·0	−0·7	3·38	+0·08	3·66	+2·60	76	4·70	20
*October	72	−4	43·5	22·3	32·9	....	......	....	0·22	....	......	......	......
Averages and totals	88·8	34·3	72·1	42·4	57·3	+4·81 (net)	22·31	−5·51 (net)	10·98	+2·93 (net)	68·2	4·77	.....

*Not included in averages or totals.

SEASON'S RESULTS

The results of the past season's work are given in the following pages and on the "Plot Series Record Sheets" which are attached to this report.

Rotation Schedules

"A"—Alfalfa five years—potatoes—wheat—flax.
"B"—Clover three years—corn—beets—oats—wheat—oats.
"C"—Grass three years—potatoes—barley—wheat.
"D"—Clover two years—wheat—barley.
"E"—Peas—wheat—oats—barley.

During 1925 the water requirement of wheat was determined under five different conditions of soil fertility, namely:—

1. As the second crop following four years alfalfa.
2. As the fourth crop following three years clover.
3. As the third crop following three years of grass.
4. As the first crop following two years of clover.
5. As the first crop following one year of peas.

The water requirements of oats were determined under three conditions of fertility, barley under three, potatoes under two and flax under one.

By following this rotation schedule it is possible to have, in each year, grain crops coming immediately after legumes, and grains or grasses, the second

and third years after legumes; thus giving an opportunity of securing data to the effect that as the soil fertility decreases, the amount of water required to produce a given yield per acre increases.

Wheat.—In rotation " A " the maximum yield, 56.5 bushels per acre, was produced under a total depth received of 2.10 feet.

In rotation " B " the maximum yield, 46.9 bushels per acre, was produced under a total depth received of 1.86 feet.

In rotion " C " the maximum yield, 35.8 bushels per acre, was produced under a total depth received of 2.56 feet.

In rotation " D " the maximum yield, 63.2 bushels per acre, was produced under a total depth received of 1.61 feet.

In rotation " E " the maximum yield, 55.3 bushels per acre, was produced under a total depth received of 2.23 feet.

Summarizing the results of the five wheat series it is shown that the maximum yields were produced with an average total depth received of 2.07 feet of which from 0.53 to 0.60 foot was received as rainfall.

The maximum yield of the five series, 63.2 bushels per acre, was produced on land that had been in clover for two years previous.

Oats.—In rotation " B " the maximum yield, 132.2 bushels per acre, was produced under a total depth received of 0.86 foot. In rotation " B-1 " the maximum yield, 118 bushels per acre, was produced under a total depth received of 2.56 feet. In rotation " E " the maximum yield, 108.2 bushels per acre, was produced under a total depth received of 0.86 foot.

Summarizing the results from the three oat series it is shown that the maximum yields were produced with an average total depth received of 1.43 feet, of which from 0.53 to 0.56 foot was rainfall. The maximum yield of the series, 132.2 bushels per acre, was produced on land that had been in alfalfa the year previous.

Barley.—In rotation " D " the maximum yield, 96 bushels per acre, was produced under a total depth received of 1.27 feet.

In rotation " C " the maximum yield, 82.7 bushels per acre, was produced under a total depth received of 1.93 feet.

In rotation " E " the maximum yield, 68 bushels per acre, was produced under a total depth received of 2.61 feet.

Summarizing the results from the three barley series it is shown that the maximum yields were produced under an average total depth received of 1.94 feet, of which 0.60 foot was rainfall.

The maximum yield of the three series, 96 bushels per acre, was produced on land that had been in clover in 1923 and wheat in 1924.

Flax.—In rotation "A" the maximum yield of flax, 33 bushels per acre, was produced under a total depth received of 2.13 feet.

Alfalfa Hay.—In rotation "A", 1921 seeding, the maximum yield, 6.62 tons per acre, was produced under a total depth received of 2.63 feet, of which 0.63 foot was rainfall.

In rotation "A", 1923 seeding, the maximum yield, 6.44 tons per acre, was produced under a total depth received of 3.63 feet, of which 0.63 foot was rainfall.

In rotation "A", 1924 seeding, the maximum yield, 6.27 tons per acre, was produced under a total depth received of 2.98 feet, of which 0.48 foot was rainfall.

Summarizing the result of the three seedings, it is shown that the maximum yields were produced under an average total depth received of 3.08 feet.

Peas.—The maximum yield of peas, 33.2 bushels per acre, was produced under a total depth received of 2.10 feet, of which 0.60 foot was rainfall.

Potatoes.—In rotation "A" the maximum yield, 489.9 bushels per acre, was produced under a total depth received of 1.61 feet, of which 0.93 foot was rainfall. In rotation "C" the maximum yield, 371.8 bushels per acre, was produced under a total depth received of 1.68, of which 0.93 was rainfall.

Sugar Beets.—In rotation "B" the maximum yield, 20.7 tons per acre, was produced under a total depth received of 2.43 feet, of which 0.93 foot was rainfall.

Northwestern Dent Corn.—In rotation "B" the maximum yield, 11.84 tons of stover per acre, was produced under a total depth received of 1.97 feet, of which 0.72 foot was rainfall.

Mixed Hay Grass.—In rotation "C" the maximum yield, 1.58 tons per acre, was produced under a total depth received of 1.79 feet, of which 0.46 foot was rainfall.

Irrigation Experiment Station, Brooks, Alberta—Plot Series Record 1925—Wheat (Marquis)

ROTATION A

Plot No.	Irrigation Date and Depth Applied in Acre-feet per Acre														Duty of Water	Rainfall April First to Harvest	Total Depth Received	Total Depth used in Growing Crop	Yield per Acre	Cut
	June						July						August							
	9	11	16	19	26	30		3	14	22			5							
44 A															0·00	0·53	0·53	0·85	20·0	Aug. 3
44 B		0·33													0·33	0·53	0·86	1·26	36·6	" 3
44 C		0·33		0·34											0·67	0·53	1·20	1·40	42·9	" 3
44 D	0·33			0·33					0·34						1·00	0·53	1·53	1·60	44·7	" 11
44 E	0·33			0·33					0·34	0·33					1·33	0·53	1·86	1·48	49·1	" 15
45 A		0·33		0·33					0·34	0·33			0·34		1·67	0·60	2·27	1·90	49·1	" 19
45 B		0·33	0·33					0·34	0·33	0·33			0·34		2·00	0·60	2·60	2·24	42·0	" 19
45 C		0·50				0·50									1·00	0·53	1·53	1·69	53·5	" 11
45 D		0·50				0·50				0·50					1·50	0·60	2·10	1·43	52·2	" 20
45 E		0·50			0·50								0·50		1·50	0·60	2·10	2·05	*56·5*	" 20

ROTATION B

Plot No.	June						July						August							
	2		17	19	....	30	3		13	22	24		5							
60 A															0·00	0·53	0·53	1·00	9·8	Aug. 1
60 B	0·33														0·33	0·53	0·86	1·02	34·1	" 12
60 C	0·33			0·34											0·67	0·53	1·20	1·18	37·7	" 12
60 D	0·33			0·33					0·34						1·00	0·53	1·53	1·63	36·5	" 12
60 E	0·33			0·33					0·34	0·33					1·33	0·53	1·86	1·55	*46·9*	" 12
61 A	0·33			0·33					0·34	0·33			0·34		1·67	0·53	2·20	1·86	43·8	" 15
61 B	0·33		0·33				0·34		0·33		0·33		0·34		2·00	0·53	2·53	2·29	46·7	" 15
61 C	0·50					0·50									1·00	0·53	1·53	2·04	37·3	" 12
61 D	0·50					0·50				0·50					1·50	0·53	2·03	2·28	34·2	" 12
61 E																				

ROTATION C

Plot No.	June						July						August							
		6		16	19	29	3		11	14	22		4							
89–90 A															0·00	0·53	0·53	0·51	12·0	Aug. 12
B		0·33													0·34	0·53	0·87	1·05	26·6	" 12
C		0·33			0·33										0·67	0·53	1·20	0·92	22·2	" 12
D		0·33			0·33				0·34						1·00	0·53	1·53	1·43	32·6	" 12
E		0·33			0·33				0·34		0·33				1·33	0·53	1·86	1·93	33·1	" 12
F		0·33			0·33				0·34		0·33		0·34		1·67	0·53	2·20	2·44	33·7	" 12
G		0·33		0·33			0·33			0·33	0·33		0·34		2·00	0·56	2·56	2·61	*35·8*	" 15

Irrigation Experiment Station, Brooks, Alberta—Plot Series Record 1925—Wheat (Marquis)—Con.

ROTATION D

Plot No.	Irrigation Date and Depth Applied in Acre-feet per Acre — June 3	June	June 17	June 20	June 25	June 29	July 3	July 11	July 13	July 15	July 22	July	August 5	August	Duty of Water	Rainfall April First to Harvest	Total Depth Received	Total Depth used in Growing Crop	Yield per Acre	Cut
76–77 A	....	....	....	....	....	....	....	....	....	....	....	....	....	....	0·00	0·53	0·53	1·10	16·0	Aug. 1
B	0·33	....	....	....	....	....	....	....	....	....	....	....	....	....	0·33	0·53	0·86	1·35	57·7	" 3
C	0·33	....	....	0·34	....	....	....	....	....	....	....	....	....	....	0·67	0·63	1·20	1·48	63·1	" 3
D	0·33	....	....	0·33	....	....	....	0·34	....	....	....	....	....	....	1·00	0·53	1·53	2·03	55·7	" 11
E	0·33	....	....	0·33	....	....	....	0·34	....	....	0·33	....	....	....	1·33	0·53	1·86	2·22	57·7	" 11
F	0·33	....	....	0·33	....	....	....	0·34	....	....	0·33	....	0·34	....	1·67	0·60	0·27	2·55	62·9	" 16
G	0·33	....	0·33	....	....	....	0·33	....	0·34	....	0·33	....	0·34	....	2·00	0·60	2·60	2·70	54·4	" 16
H	0·50	....	....	....	....	0·50	....	....	....	....	....	....	....	....	1·00	0·61	1·61	1·82	*63·2*	" 19
J	0·50	....	....	....	....	0·50	....	....	....	....	0·50	....	....	....	1·50	0·56	2·06	2·23	56·8	" 15
K	0·50	....	....	....	0·50	....	....	....	....	0·50	....	....	0·50	....	2·00	0·56	2·56	2·41	55·7	" 15

ROTATION E

Plot No.	June 6	June	June 17	June 20	June 23	June 25	July 2	July 4	July 11	July 14	July 16	July 24	August 4	August						
25 A	....	....	....	....	....	....	....	....	....	....	....	....	....	....	0·00	0·53	0·53	0·67	35·1	Aug. 8
24 A	0·33	....	....	....	....	....	....	....	....	....	....	....	....	....	0·33	0·53	0·86	1·34	51·2	" 11
25	0·33	....	....	0·34	....	....	....	....	....	....	....	....	....	....	0·67	0·53	1·20	1·37	37·7	" 10
24	0·33	....	....	0·33	....	....	....	....	0·34	....	....	....	....	....	1·00	0·53	1·53	1·30	46·3	" 11
23	0·33	....	....	0·33	....	....	....	....	0·34	....	....	0·33	....	....	1·33	0·56	1·89	2·17	51·2	" 15
22	0·33	....	....	....	0·33	....	....	....	0·34	....	....	0·33	0·34	....	1·67	0·56	2·23	2·00	*55·3*	" 15
21	0·33	....	0·33	....	....	....	....	0·34	....	0·33	....	0·33	0·34	....	2·00	0·56	2·56	3·15	48·1	" 15
23 A	0·50	....	....	....	....	....	0·50	....	....	....	....	....	....	....	1·00	0·60	1·60	1·82	50·9	" 20
22 A	0·50	....	....	....	....	....	0·50	....	....	....	....	0·50	....	....	1·50	0·60	2·10	1·99	49·6	" 20
21 A	0·50	....	....	....	....	0·50	....	....	....	....	0·50	....	0·50	....	2·00	0·60	2·60	2·83	44·6	" 20

Irrigation Experiment Station, Brooks, Alberta—Plot Series Record 1925—Oats (Banner)

ROTATION B

Plot No.	Irrigation Date and Depth Applied in Acre-feet per Acre — June 5	June	June 17	June 19	June 25	June 29	July 3	July 11	July 13	July 15	July 22	July	August 5	August 6	Duty of Water	Rainfall April First to Harvest	Total Depth Received	Total Depth used in Growing Crop	Yield per Acre	Cut
64 A	....	....	....	....	....	....	....	....	....	....	....	....	....	....	0·00	0·53	0·53	0·61	20·5	Aug. 11
64 B	0·33	....	....	0·34	....	....	....	0·33	....	....	0·34	....	0·33	....	1·67	0·53	2·23	1·80	114·0	" 15
64 C	0·33	....	....	0·34	....	....	....	....	....	....	....	....	....	....	0·67	0·53	1·20	1·36	84·6	" 11
64 D	0·33	....	....	0·33	....	....	....	0·34	....	....	....	....	....	....	1·00	0·53	1·53	1·72	111·0	" 11
64 E	0·33	....	....	0·33	....	....	....	0·34	....	....	0·33	....	....	....	1·33	0·56	1·89	1·69	111·9	" 15
65 A	0·33	....	....	....	....	....	....	....	....	....	....	....	....	....	0·33	0·53	0·86	1·40	*132·2* *	" 11
65 B	0·33	....	0·33	....	....	....	0·34	....	0·33	....	0·33	....	....	0·34	2·00	0·56	2·56	2·17	120·6	" 15
65 C	0·50	....	....	....	....	0·50	....	....	....	....	....	....	....	....	1·00	0·53	1·53	1·40	100·2	" 11
65 D	0·50	....	....	....	....	0·50	....	....	....	....	0·50	....	....	....	1·50	0·56	2·06	1·33	118·4	" 15
65 E	0·50	....	....	....	0·50	....	....	....	....	0·50	....	....	....	0·50	2·00	0·56	2·56	2·05	122·5	" 15

*Off curve.

ROTATION B–1

Plot No.	June 4	June	June 17	June 19	June 25	June 30	July 3	July 11	July 15	July 22	July	July	August 5	August						
58 A	....	....	....	....	....	....	....	....	....	....	....	....	....	....	0·00	0·53	0·53	0·87	93·8	Aug. 11
58 B	0·33	....	....	....	....	....	....	....	....	....	....	....	....	....	0·33	0·53	0·86	0·88	92·3	" 11
58 C	0·33	....	....	0·34	....	....	....	....	....	....	....	....	....	....	0·67	0·56	1·23	1·35	104·1	" 15
58 D	0·33	....	....	0·33	....	....	....	0·34	....	....	....	....	....	....	1·00	0·56	1·56	1·50	100·6	" 15
58 E	0·33	....	....	0·33	....	....	....	0·34	....	0·33	....	....	....	....	1·33	0·56	1·89	1·89	98·0	" 15
59 A	0·33	....	....	0·33	....	....	....	0·34	....	0·33	....	....	0·34	....	1·67	0·56	2·23	2·08	107·5	" 15
59 B	0·33	....	0·33	....	....	....	0·34	0·33	....	0·33	....	....	0·34	....	2·00	0·56	2·56	2·28	*118·0*	" 15
59 C	0·50	....	....	....	....	0·50	....	....	....	....	....	....	....	....	1·00	0·56	1·56	1·76	117·9	" 15
59 D	0·50	....	....	....	....	0·50	....	....	....	0·50	....	....	....	....	1·50	0·56	2·06	1·77	117·8	" 15
59 E	0·50	....	....	....	0·50	....	....	....	0·50	....	....	....	0·50	....	2·00	0·56	2·56	2·41	110·3	" 15

Irrigation Experiment Station, Brooks, Alberta—Plot Series Record 1925—Oats (Banner)—Con.

ROTATION E

Plot No.	Irrigation Date and Depth Applied in Acre-feet per Acre — June						July						August		Duty of Water	Rainfall April First to Harvest	Total Depth Received	Total Depth used in Growing Crop	Yield per Acre	Cut
	8	9	11	17	22	25	2	4	11	13	14	24	4							
36 A	....	....	....	....	....	....	....	....	....	....	....	....	....	....	0·00	0·53	0·53	1·22	79·6	Aug. 5
37 A	....	....	0·33	....	....	....	....	....	....	....	....	....	....	....	0·33	0·53	0·86	......	*108·2*	" 5
36	....	....	0·33	....	0·34	....	....	....	....	....	....	....	....	....	0·67	0·53	1·20	1·66	81·9	" 5
37	....	....	0·33	....	0·34	....	....	....	....	0·33	....	....	....	....	1·00	0·53	1·53	1·95	90·3	" 5
38	....	0·33	....	....	0·33	....	....	....	....	0·34	....	0·33	....	....	1·33	0·53	1·86	2·15	99·7	" 10
39	....	0·33	....	....	0·33	....	....	....	0·34	....	....	0·33	0·34	....	1·67	0·53	2·20	2·43	102·7	" 10
40	....	0·33	....	0·33	....	....	....	0·34	....	....	0·33	0·33	0·34	....	2·00	0·53	2·53	2·97	93·4	" 10
38 A	....	0·50	....	....	....	....	0·50	....	....	....	....	....	....	....	1·00	0·53	1·53	2·12	99·2	" 10
39 A	....	0·50	....	....	....	....	0·50	....	....	....	....	0·50	....	....	1·50	0·53	2·03	2·19	101·8	" 10
40 A	0·50	....	....	....	....	0·50	....	....	....	....	0·50	....	0·50	....	2·00	0·53	2·53	3·01	86·1	" 10

Irrigation Experiment Station, Brooks, Alberta—Plot Series Record 1925—Barley (Banks)

ROTATION "C"

Plot No.	Irrigation Date and Depth Applied in Acre-Feet per Acre — June						July						August		Duty of Water	Rainfall April First to Harvest	Total Depth Received	Total Depth used in Growing Crop	Yield per acre	Cut
		12	15		25		3	9	10	16	17	25	4							
															Ft.	Ft.	Ft.	Ft.	Bush	
92 A	....	....	....	....	....	....	....	....	....	....	....	....	....	....	0·00	0·60	0·60	0·96	32·1	
92 B	....	....	0·33	....	....	....	....	....	....	....	....	....	....	....	0·33	0·60	0·93	1·08	43·2	
92 C	....	....	0·33	....	....	....	0·34	....	....	....	....	....	....	....	0·67	0·60	1·27	......	49·1	
92 D	....	....	0·33	....	....	....	0·33	....	....	0·34	....	....	....	....	1·00	0·60	1·60	1·86	53·2	
91 A	....	....	0·33	....	....	....	0·33	....	....	0·34	....	0·33	....	....	1·33	0·60	1·93	2·19	82·7	
91 B	....	....	0·33	....	....	....	0·33	....	....	0·34	....	0·33	0·34	....	1·67	0·60	2·27	2·24	60·6	
91 C	....	....	0·33	....	0·33	....	....	....	0·34	....	0·33	0·33	0·34	....	2·00	0·60	2·60	2·61	58·5	
91 D	....	....	....	....	....	....	....	0·50	....	....	....	....	....	....	1·00	0·60	1·60	1·87	61·8	
91 E	....	0·50	....	....	....	....	....	0·50	....	....	....	0·50	....	....	1·50	0·60	2·10	1·95	65·9	

ROTATION "D"

Plot No.	June						July						August							Cut
			15		25	30	3		10	15	17	28	6							
74 A	....	....	....	....	....	....	....	....	....	....	....	....	....	....	0·00	0·60	0·60	0·73	45·8	Aug. 18
B	....	....	0·33	....	....	....	....	....	....	....	....	....	....	....	0·33	0·60	0·93	0·84	92·9	" 18
C	....	....	0·33	....	....	....	0·34	....	....	....	....	....	....	....	0·67	0·60	1·27	1·12	96·0	" 20
D	....	....	0·33	....	....	....	0·33	....	....	0·34	....	....	....	....	1·00	0·60	1·60	1·40	87·6	" 20
E	....	....	0·33	....	....	....	0·33	....	....	0·34	....	0·33	....	....	1·33	0·60	1·93	1·93	83·9	" 20
75 A	....	....	0·33	....	....	....	0·33	....	....	0·34	....	0·33	0·34	....	1·67	0·60	2·27	2·12	81·2	" 20
B	....	....	0·33	....	0·33	....	....	....	0·34	....	0·33	0·33	0·34	....	2·00	0·60	2·60	2·52	75·1	" 20
C	....	....	0·50	....	....	....	....	....	0·50	....	....	....	....	....	1·00	0·60	1·60	1·52	90·6	" 20
D	....	....	0·50	....	....	....	....	....	0·50	....	....	0·50	....	....	1·50	0·60	2·10	2·05	88·5	" 20
E	....	....	0·50	....	....	0·50	....	....	0·50	....	....	....	0·50	....	2·00	0·60	2·60	2·67	73·2	" 20

ROTATION "E"

Plot No.	June						July						August							Cut
		16		26			4	10		15	17	23	5							
5 A	....	....	....	....	....	....	....	....	....	....	....	....	....	....	0·00	0·60	0·60	0·55	44·1	Au . 20
4 A	....	0·33	....	....	....	....	....	....	....	....	....	....	....	....	0·33	0·60	0·93	0·70	59·9	" 20
5	....	0·33	....	....	....	....	0·34	....	....	....	....	....	....	....	0·67	0·60	1·27	1·30	48·8	" 20
4	....	0·33	....	....	....	....	0·33	....	....	0·34	....	....	....	....	1·00	0·60	1·60	1·67	60·2	" 20
3	....	0·33	....	....	....	....	0·33	....	....	0·34	....	0·33	....	....	1·33	0·60	1·93	2·03	62·7	" 20
2	....	0·33	....	....	....	....	0·33	....	....	0·34	....	0·33	0·34	....	1·67	0·60	2·27	2·25	63·4	" 20
1	....	0·33	....	0·33	....	....	....	0·34	....	....	0·33	0·34	0·33	....	2·00	0·61	2·61	2·70	68·0	" 24
3 A	....	0·50	....	....	....	....	....	0·50	....	....	....	....	....	....	1·00	0·60	1·60	1·67	63·9	" 20
2 A	....	0·50	....	....	....	....	....	0·50	....	....	....	0·50	....	....	1·50	0·61	2·11	2·07	67·6	" 24
1 A	....	0·50	....	....	....	....	....	0·50	....	....	....	0·50	0·50	....	2·00	0·61	2·61	2·56	60·0	" 24

Irrigation Experiment Station, Brooks, Alberta—Plot Series Record 1925—Flax (Primost)

ROTATION "A"

Plot No.	Irrigation Date and Depth Applied in Acre-feet per Acre — June 12	June 16	June 20	June 26	June 30	July 3	July 13	July 23				August 5		Duty of Water	Rainfall April First to Harvest	Total Depth Received	Total Depth used in Growing Crop	Yield per acre	Cut
42 A														0·00	0·53	0·53	0·81	8·7	Aug. 3
B	0·33													0·33	0·53	0·86	0·92	16·6	" 11
C	0·33		0·34											0·67	0·61	1·28	0·99	29·6	" 25
D	0·33		0·33				0·34							1·00	0·61	1·61	1·42	32·0	" 25
E	0·33		0·33				0·34	0·33						1·33	0·61	1·94	2·08	29·3	" 25
43 A	0·33		0·33				0·34	0·33				0·34		1·67	0·61	2·28	1·96	28·4	Sept. 4
B	0·33	0·33				0·33	0·34	0·33				0·34		2·00	0·61	2·61	2·34	24·4	" 4
C	0·50				0·50									1·00	0·61	1·61	1·16	26·4	" 4
D	0·50				0·50			0·50						1·50	0·63	2·13	2·10	33·0	" 4
E	0·50			0·50								0·50		1·50	0·63	2·13	1·70	29·9	" 14

Irrigation Experiment Station, Brooks, Alberta—Plot Series Record 1925—Alfalfa (Grimm, 1921 seeding)

ROTATION, A—4849

Plot No.	Irrigation Date and Depth Applied in Acre-feet per Acre — May 29	June 1	June 12	June 20	July 8	July 10	July 13	July 15	July 20	July 25	Aug. 11	Duty of Water	Rainfall April First to Harvest	Total Depth Received	Total Depth used in Growing Crop	Yield per acre	Cut
48 A												0·00	0·63	0·63	0·62	0·22	
B			0·50									0·50	0·63	1·13	1·26	1·09	
C			0·50			0·50						1·00	0·63	1·63	1·93	4·20	
D		0·50		0·50				0·50				1·50	0·63	2·13	2·12	5·47	
E	0·50		0·50		0·50				0·50			2·00	0·63	2·63	2·41	6·62	
49 A	0·50		0·50		0·50		0·50			0·50		2·50	0·63	3·13	3·18	6·45	
B	0·50		0·50		0·50		0·50			0·50	0·50	3·00	0·63	3·63	3·55	5·67	
C	0·33		0·33		0·33			0·34				1·33	0·63	1·96	2·96	5·25	
D	0·33		0·33		0·33		0·34			0·34		1·67	0·63	2·30	......	5·24	
E	0·33		0·33		0·33		0·33			0·34	0·34	2·00	0·63	2·63	3·13	6·04	

ROTATION A—5253 (1923—Seeding)

Plot No.	May	June 1	June 12	June 20	July 9	July 10	July 15	July 20	July 25		Aug. 11						Cut
52 A												0·00	0·63	0·63	0·92	0·15	
52 B			0·50									0·50	0·63	1·13	1·21	1·84	
52 C			0·50			0·50						1·00	0·63	1·63	1·75	2·93	
52 D		0·50		0·50			0·50					1·50	0·63	2·13	1·75	5·33	
53 A		0·50	0·50			0·50		0·50			0·50	2·00	0·63	2·63	2·80	5·62	
53 B		0·50	0·50		0·50		0·50		0·50		0·50	2·50	0·63	3·13	3·12	6·20	
53 C		0·50	0·50		0·50		0·50		0·50		0·50	3·00	0·63	3·63	3·60	6·44	

ROTATION A—5455 (1924—Seeding)

Plot No.	May 28	June 3	June 8	June 12	June 19	June 25	July 9	July 14	July 20	July 27	Aug. 12						Cut
54 A						0·50						0·50	0·48	0·98	1·57	4·72	
54 B				0·50		0·50						1·00	0·48	1·48	1·77	5·33	Yield off due to seepage should be about 5·50
54 C			0·50				0·50					1·00	0·48	1·48	1·95	4·21	
54 D		0·50			0·50			0·50				1·50	0·48	1·98	2·08	5·70	
54 E	0·50			0·50			0·50		0·50			2·00	0·48	2·48	2·14	5·55	
55 A	0·50			0·50				0·50		0·50		2·00	0·48	2·48	2·53	5·67	
55 B	0·50			0·50				0·50		0·50	0·50	2·50	0·48	2·98	3·14	6·27	

Irrigation Experiment Station, Brooks, Alberta—Plot Series Record 1925—Peas (Prussian Blue)

ROTATION "E".

Plot No.	Irrigation Date and Depth Applied in Acre-feet per Acre												Duty of Water	Rainfall April First to Harvest	Total Depth Received	Total Depth used in Growing Crop	Yield per acre	Cut
	June						July					Aug.						
	5	6	8	17	20	25	4	11	14	16	23	5						
16 A	....	....	....	....	....	....	....	....	....	....	....	......	0·00	0·60	0·60	0·73	23·8	Aug. 20
17 A	....	0·23	....	....	....	....	....	....	....	....	....	......	0·33	0·60	0·93	0·93	29·2	" 20
16	0·33	....	....	....	0·34	....	....	....	....	....	....	......	0·67	0·60	1·27	1·37	31·6	" 20
17	0·33	....	....	....	0·33	....	....	0·34	....	....	....	......	1·00	0·60	1·60	2·04	19·6	" 20
18	....	....	0·33	....	0·33	....	....	0·34	....	....	0·33	......	1·33	0·60	1·93	2·29	25·7	" 21
19	....	0·33	....	....	0·33	....	....	0·34	....	....	0·33	0·34	1·67	0·60	2·27	2·58	31·8	" 21
20	....	0·33	....	0·33	....	....	0·34	....	0·33	....	0·33	..0·34	2·00	0·60	2·60	3·15	32·9	" 21
18 A	....	0·50	....	....	....	....	0·50	....	....	....	....	......	1·00	0·60	1·60	1·90	32·6	" 22
19 A	....	0·50	....	....	....	....	0·50	....	....	....	0·50	......	1·50	0·60	2·10	2·51	33·2	" 22
20 A	....	0·50	....	....	....	0·50	....	....	....	0·50	....	0·50	2·00	0·60	2·60	3·36	29·3	" 22

Irrigation Experiment Station, Brooks, Alberta—Plot Series Record 1925—Potatoes (Netted Gem)

ROTATION "A"

Plot No.	Irrigation Date and Depth Applied in Acre-feet per Acre										Duty of Water	Rainfall April First to Harvest	Total Depth Received	Total Depth used in Growing Crop	Yield per Acre	Dug
	June	July					August			Sept.						
	20	6	13	15	20	25	12	18	26	11						
46A	......	....	....	....	....	....	....	....	....	......	0·00	0·93	0·93	0·50	94·0	Oct. 7–9
B	......	....	....	0·17	....	....	....	....	....	......	0·17	0·93	1·10	0·53	138·5	
C	......	0·17	....	....	....	....	0·17	....	....	......	0·34	0·93	1·27	1·10	226·0	
D	0·17	....	....	....	0·17	....	....	0·17	....	......	0·51	0·93	1·44	1·43	426·5	
E	0·17	....	....	0·17	....	....	0·17	....	....	0·17	0·68	0·93	1·61	1·44	*489·9*	
47A	0·17	....	0·17	....	....	0·17	....	0·17	....	0·17	0·85	0·93	1·78	1·63	482·2	
B	0·17	....	0·17	....	....	0·17	0·17	....	0·17	0·17	1·02	0·93	1·95	1·76	486·2	
C	......	0·25	....	....	....	....	0·25	0·25	....	......	0·75	0·93	1·68	1·23	475·8	
D	0·25	....	....	....	0·25	....	....	....	....	......	0·50	0·93	1·43	1·18	470·4	
E	0·25	....	....	0·25	....	....	0·25	....	....	0·25	1·00	0·93	1·93	1·66	418·3	

ROTATION "C"

Plot No.	June	July					August			Sept.						
	20	6	14	15	20	25	11	18	25	10						
9394A	......	....	....	....	....	....	....	....	....	......	0·00	0·93	0·93	......	72·7	
B	......	....	....	0·17	....	....	....	....	....	......	0·17	0·93	1·10	0·80	154·0	
C	......	0·17	....	....	....	....	0·17	....	....	......	0·34	0·93	1·27	1·04	259·0	
D	0·17	....	....	....	0·17	....	....	0·17	....	......	0·51	0·93	1·44	1·04	298·0	
E	0·17	....	....	0·17	....	....	0·17	....	....	0·17	0·68	0·93	1·61	1·33	344·6	
F	0·17	....	0·17	....	....	0·17	....	0·17	....	0·17	0·85	0·93	1·78	1·26	348·0	
G	0·17	....	0·17	....	....	0·17	0·17	....	0·17	0·17	1·02	0·93	1·95	1·64	327·6	
H	......	0·25	....	....	....	....	0·25	0·25	....	......	0·75	0·93	1·68	1·45	*371·8*	
K	0·25	....	....	....	0·25	....	....	....	....	......	0·50	0·93	1·43	1·04	319·3	
L	0·25	....	....	0·25	....	....	0·25	....	....	0·25	1·00	0·93	1·93	1·64	289·1	

Irrigation Experiment Station, Brooks, Alberta—Plot Series Record 1925—Sugar Beets (Kleinwanzkebener)

ROTATION "B"

Plot No.	Irrigation Date and Depth Applied in Acre-feet per Acre										Duty of Water	Rainfall April First to Harvest	Total Depth Received	Total depth used in Growing Crop	Yield per Acre	Sugar Content Percent.	Lbs. of Sugar per Acre
	June		July				August			Sept.							
	26	27	15	21	25	30	11	18	26	9							
62A											0·00	0·93	0·93	0·93	3·2	15·9	850
62B				0·375							0·375	0·93	1·305	1·02	10·2	14·9	2,471
63A	0·375			0·375							0·75	0·93	1·680	1·65	17·7	14·3	4,059
62D		0·375		0·375				0·33			1·08	0·93	2·010	1·59	18·3	16·2	5,104
62E		0·375		0·375	0·375	0·375		0·33			1·455	0·93	2·385	2·20	16·5	14·5	3,965
62C		0·375	0·375	0·375			0·375	0·33			1·83	0·93	2·760	2·01	18·5	15·2	4,632
63B		0·375	0·375		0·375		0·375		0·375	0·375	2·25	0·93	3·180	2·13	17·3	14·7	4,273
63C		0·25		0·250							0·50	0·93	1·43	1·16	15·4	13·4	3,367
63D	0·250			0·250				0·25			0·75	0·93	1·68	1·23	15·5	14·7	3,729
63E	0·250		0·250		0·250		0·250		0·250	0·250	1·50	0·93	2·43	1·70	20·7	14·4	4,933

Irrigation Experiment Station, Brooks, Alberta—Plot Series Record 1925—Corn (Northwestern Dent)

ROTATION "B"

Plot No.	Irrigation Date and Depth Applied in Acre-feet per Acre											Duty of Water	Rainfall April First to Harvest	Total Depth Received	Total Depth used in Growing Crop	Yield per Acre	Remarks
	June	July					August				Sept.						
		6	16	22	25	30	5	11	18	25	10						
66A												0·00	0·72	0·72	0·68	4·90	Tons of
B		0·25										0·25	0·72	0·97	0·82	6·09	Stover.
C		0·25				0·25						0·50	0·72	1·22	1·47	7·60	
D		0·25		0·25				0·25				0·75	0·72	1·47	1·79	8·26	
E		0·25		0·25			0·25			0·25		1·00	0·72	1·72	1·93	8·54	
67A		0·25		0·25		0·25			0·25		0·25	1·25	0·72	1·97	2·15	*11·89*	
B		0·25	0·25		0·25			0·25		0·25	0·25	1·50	0·72	2·22	2·17	7·50	
C		·375		·416			·416			·416		1·623	0·72	2·34	......	9·34	
D		·375		·416				·416				1·207	0·72	1·92	......	9·40	
E		·375				·416						0·791	0·72	1·51	......	8·44	

Irrigation Experiment Station, Brooks, Alberta—Plot Series Record 1925—Grasses (Mixed)

ROTATION "C"

Plot No.	Irrigation Date and Depth Applied in Acre-feet per Acre							Duty of Water	Rainfall April First to Harvest	Total Depth Received	Total Depth used in Growing Crop	Yield per Acre	Remarks
	May	June											
	22	1	2	8	15	19	22					Tons	
83C								0·00	0·46	0·46	......	1·29	
B	0·33							0·33	0·46	0·79	......	0·87	
A	0·33			0·34				0·67	0·46	1·13	......	1·23	
D	0·33		0·33		0·34			1·00	0·46	1·46	......	0·93	
E	0·33		0·33		0·34			1·00	0·46	1·46	......	0·94	
84A	0·33	0·33		0·34		0·33		1·33	0·46	1·79	......	1·58	
B	0·33	0·33		0·34	0·33		0·34	1·67	0·46	2·13	......	1·25	
C	0·50			0·50				1·00	0·46	1·46	......	1·49	
D	0·50		0·50		0·50			1·50	0·46	1·96	......	1·34	
E	0·50		0·50		0·50			1·50	0·46	1·96	......	1·24	

FARM DEMONSTRATION AND EXTENSION WORK, 1925

A conference of those who advise the farmers of the irrigated lands in the vicinity of Lethbridge was held at Lethbridge, Alberta, on April 21. In attendance were representatives of the Dominion and Provincial Departments of Agriculture; of the Dominion Water Power and Reclamation Service, Department of the Interior; and of the Lethbridge Northern Irrigation district. The purpose of the conference was to formulate plans for work among the settlers of the Lethbridge Northern Irrigation district during 1925 in order to secure a co-ordination of effort and a standardization of advice to irrigators. Among the subjects discussed were: 1. The proper size, gradient, and location of farm laterals and the technical assistance needed to provide each farmer with about 40 acres of surveyed laterals. 2. The amount of water required for the different crops and how best to apply it. 3. The culture and seeding of alfalfa and sweet clover.

On May 20 the Commissioner of Irrigation placed seven engineers in the field to locate farm laterals for the farmers of the Lethbridge Northern and New West Irrigation districts. Six engineers were located in the former and one in the latter district.

The farmers made application for ditch surveys to the local watermasters who listed the applications and advised the engineers as to where ditches were required. The engineers were instructed to locate laterals on each farm unit for at least forty acres and if advisable to locate additional laterals at some later date if the farmer had made good use of the laterals previously located. During the month laterals covering 2,308 acres were located on 56 farms.

During June laterals were located on an additional 6,441 acres, making a total area surveyed up to June 30 of 8,749 acres. By the end of June every farmer desiring field laterals surveyed had been served. Many farmers were visited the second time and supplied with laterals for additional areas.

Heavy rains during the last two weeks in June led many farmers to postpone irrigation which proved to be very unwise as the crop not irrigated in June suffered from drought in July.

Twelve farmers were supplied with laterals during July. As many as possible of the farmers supplied with ditches were visited at this time for the purpose of advising them in their irrigation work and encouraging them to apply the correct amount of water in the proper manner. They were shown by means of soil moisture tests, what condition their land was in as regards moisture and advised when to irrigate.

In general the extension work carried out by the Dominion Water Power and Reclamation Service during 1925 was productive of excellent results. Due to the assistance afforded in supplying proper ditch locations and to the advice provided regarding the best irrigation practice the water users were encouraged to take fuller advantage of their opportunities to benefit by irrigation and as a result crops produced showed a marked improvement over those harvested on the same lands in 1924.

Tables showing meteorological records obtained at Ronalane, Vauxhall, Coaldale Brooks, and Strathmore for the period 1915-25.

—	NW. 5-13-12—RONALANE El. 2330							VAUXHALL El. 2550—SE. 10-13-16				Monthly and seasonal averages 1915–1925
	Precipitation							Precipitation				
	1915	1916	1917	1918	1919	1920	1921	1922	1923	1924	1925	
April.........	0·09	0·14	0·84	0·21	2·34	0·90	0·62	2·48	0·93	0·17	1·71	0·95
May..........	1·69	2·33	0·76	0·65	1·62	1·54	1·74	0·80	1·63	0·56	0·40	1·24
June..........	4·15	4·32	1·29	1·22	0·37	0·66	0·74	1·73	5·12	1·63	2·11	2·12
July..........	3·26	4·24	0·24	1·37	0·89	2·22	1·21	1·10	2·34	0·69	0·97	1·69
August........	0·75	1·68	1·34	0·92	0·77	0·00	0·57	0·48	1·32	3·00	1·33	1·10
September....	1·29	3·14	1·53	0·22	0·83	0·03	1·96	0·59	0·00	0·77	2·95	1·21
Sums.....	11·23	15·85	6·00	4·59	6·82	5·35	6·83	7·18	11·34	6·82	9·47	8·31
	Temperature							Temperature				
April.........	51·4	43·9	57·7	42·2	45·5	33·6	42·9	41·1	40·6	40·1	44·8	44·0
May..........	53·0	48·7	51·6	49·8	53·6	50·4	52·4	54·0	54·1	52·0	51·8	51·9
June..........	56·4	57·6	57·8	64·1	63·1	50·7	66·3	60·3	61·7	56·2	60·8	60·4
July..........	61·2	65·8	69·9	65·0	67·3	69·5	68·3	66·7	67·8	66·1	65·9	66·7
August........	69·2	62·1	62·6	64·4	66·6	65·8	64·8	68·3	63·4	60·5	61·8	64·5
September....	51·5	53·3	55·1	55·0	54·6	56·9	50·7	61·5	54·9	55·5	50·6	54·5
Averages.	57·1	55·2	55·8	56·8	58·4	56·0	57·6	58·6	57·0	55·1	56·0	57·0

NW. 25-8-20—COALDALE El. 2828

	Precipitation											Monthly and seasonal averages, 1915–1925
	1915	1916	1917	1918	1919	1920	1921	1922	1923	1924	1925	
April.........	5·68	1·51	2·55	3·20	6·59	3·31	2·05	1·97	3·19	2·77	2·70	3·23
May..........	4·28	5·12	4·83	6·76	5·20	5·68	3·69	4·32	4·63	4·32	5·27	4·92
June..........	2·26	4·68	5·78	7·88	7·30	6·47	6·62	5·17	3·30	3·60	4·65	5·25
July..........	4·38	6·20	9·20	7·68	8·12	6·92	6·55	5·45	4·42	5·67	5·56	6·38
August........	4·97	4·70	5·23	6·79	6·91	5·76	6·09	5·42	3·90	4·03	5·09	5·35
September....	2·92	3·59	4·35	3·76	3·81	4·80	4·28	4·40	3·85	3·61	2·09	3·77
Sums.....	24·50	25·80	31·94	36·07	37·93	32·95	29·28	26·73	23·29	24·00	25·36	28·90
	Precipitation											
April.........	0·00	0·26	0·70	0·15	0·53	3·54	0·54	2·93	1·12	0·45	2·07	1·12
May..........	2·99	4·12	0·86	1·03	1·86	1·59	1·28	1·28	3·16	0·82	0·26	1·75
June..........	5·31	3·82	2·11	0·65	0·66	1·09	0·86	1·24	3·51	3·22	2·18	2·24
July..........	5·15	2·47	0·29	0·93	1·27	3·21	2·17	2·25	3·18	0·75	0·77	2·05
August........	0·28	3·25	1·88	1·23	1·20	0·20	0·55	0·33	1·30	3·14	1·59	1·36
September....	2·11	4·79	2·82	0·41	2·14	0·31	1·21	0·73	0·09	1·23	4·25	1·82
Sums.....	15·84	18·71	8·66	4·40	7·66	10·03	6·61	8·76	12·36	9·61	11·12	10·34
	Temperature											
April.........	50·0	44·2	39·2	42·9	45·4	31·1	41·2	38·2	41·4	41·3	45·8	41·9
May..........	51·1	48·6	49·7	44·0	49·0	47·6	51·0	51·6	53·2	53·5	54·5	50·3
June..........	54·7	56·4	56·4	63·0	58·3	57·0	62·8	61·7	60·6	56·0	61·9	59·0
July..........	59·3	63·3	68·5	64·3	65·0	69·0	64·6	64·0	66·5	65·1	67·3	65·2
August........	67·2	60·8	63·5	63·5	66·7	68·1	62·7	66·0	63·3	60·3	62·2	64·0
September....	50·4	53·6	55·1	57·4	54·8	55·4	50·3	59·0	56·5	55·8	50·1	54·4
Averages.	55·4	54·5	55·4	55·8	56·7	54·7	55·4	56·8	56·9	55·3	57·0	55·6

Tables showing meteorological records obtained at Ronalane, etc.—Con.

SE. 6-19-14—BROOKS El. 2455

—	1915	1916	1917	1918	1919	1920	1921	1922	1923	1924	1925	Monthly and seasonal averages, 1915–1925
	Evaporation											
April	....	....	....	5·68	2·47	1·05	2·64	1·71	3·73	3·16	2·50	2·87
May	....	....	....	8·47	6·07	4·28	3·69	4·73	4·89	5·24	4·42	5·22
June	....	....	....	8·50	7·33	5·73	5·77	4·52	3·22	3·97	3·95	5·38
July	....	....	....	9·57	7·15	5·15	6·29	5·35	5·13	6·24	4·39	6·16
August	....	....	....	6·80	5·21	5·65	6·01	4·64	3·18	3·24	3·67	4·80
September	....	....	....	3·84	3·21	4·12	3·22	2·82	3·12	2·53	3·38	3·27
Sums	....	....	....	42·86	31·44	25·98	27·62	23·77	23·27	24·38	22·31	27·70
	Precipitation											
April	....	....	0·58	0·00	1·41	1·16	0·95	1·94	0·78	0·46	1·67	0·99
May	....	....	1·01	0·42	1·02	0·88	1·55	1·26	0·90	1·05	0·46	0·95
June	5·41	2·27	0·89	0·54	0·40	1·52	0·21	2·09	4·19	1·50	2·41	1·95
July	1·55	2·61	1·06	1·39	1·46	1·41	1·44	0·33	1·87	1·26	1·86	1·48
August	2·07	1·80	2·45	1·15	2·40	0·00	1·46	1·70	1·75	2·41	0·92	1·65
September	0·65	2·45	0·82	0·31	1·77	0·00	2·65	1·12	0·00	0·86	3·66	1·30
Sums	....	....	6·81	3·81	8·46	4·97	8·26	8·44	9·49	7·54	10·98	8·32
	Temperature											
April	48·2	43·0	39·0	46·0	43·8	34·6	41·5	41·0	43·4	39·6	45·9	42·4
May	50·0	47·0	52·0	52·0	53·1	50·8	50·3	52·7	53·2	51·8	54·0	51·4
June	56·4	58·0	58·3	65·0	62·4	59·4	64·6	62·2	61·9	57·4	60·7	60·6
July	62·0	66·0	70·5	67·5	66·3	69·0	67·3	64·9	67·3	67·3	66·4	66·8
August	70·0	62·0	63·9	64·2	64·5	64·6	63·2	65·6	63·2	61·7	63·6	64·2
September	51·0	52·0	54·3	53·2	54·8	55·5	50·0	57·0	55·0	55·7	53·0	53·7
Averages	56·3	54·7	56·3	58·0	57·5	55·6	56·1	57·2	57·3	55·5	57·3	56·6

NE. 11-24-25—STRATHMORE El. 3190

	1915	1916	1917	1918	1919	1920	1921	1922	1923	1924	1925	Monthly and seasonal averages, 1915–1925
	Evaporation											
April	4·22	2·59	2·09	2·88	4·15	2·05	3·00	....	3·69	1·80	2·32	2·88
May	4·73	3·46	3·70	4·58	6·42	3·00	4·76	5·85	5·43	4·78	5·23	4·72
June	4·33	4·59	4·60	5·83	6·42	4·20	6·02	4·24	3·50	3·81	3·98	4·68
July	6·47	4·84	5·88	6·13	5·46	4·47	6·27	5·33	4·76	4·44	4·56	5·32
August	4·25	3·16	3·66	4·01	3·65	4·47	3·59	3·74	3·37	3·20	4·85	3·81
September	2·27	2·66	2·27	2·62	1·64	3·67	2·69	3·56	2·44	2·89	2·51	2·66
Sums	26·27	21·30	22·20	26·05	27·74	21·86	26·33	....	23·19	20·92	23·45	24·07
	Precipitation											
April	0·11	0·44	0·56	0·39	1·45	2·11	1·28	2·71	1·06	1·09	1·21	1·13
May	3·42	4·51	3·26	1·08	2·26	1·78	0·71	0·36	3·97	0·55	1·75	2·15
June	4·77	2·02	2·30	0·22	1·10	1·72	1·14	1·30	4·02	4·00	4·54	2·47
July	4·89	3·42	0·51	1·10	1·56	2·87	2·70	2·15	2·56	1·08	2·58	2·31
August	1·48	3·13	2·48	2·10	3·46	0·27	2·99	2·73	1·98	2·19	0·82	2·15
September	2·56	2·60	1·05	0·82	3·26	0·08	0·63	0·76	0·83	0·98	5·21	1·71
Sums	17·23	16·12	10·16	5·71	13·09	8·83	9·44	10·01	14·42	9·89	16·11	11·92
	Temperature											
April	46·0	41·0	35·1	41·2	41·9	27·7	38·6	35·7	38·5	37·0	47·9	39·2
May	48·6	44·4	47·2	48·5	47·4	46·0	49·2	50·2	49·8	51·4	52·4	48·7
June	51·7	53·9	54·2	59·9	56·1	55·5	60·3	54·2	54·0	54·1	55·4	55·4
July	57·2	59·1	64·9	62·6	61·7	65·0	61·8	60·7	62·3	63·3	67·1	62·4
August	64·4	56·7	59·0	55·5	60·4	60·8	58·9	61·9	59·5	58·0	59·6	59·5
September	47·0	58·5	51·6	49·0	49·5	51·3	47·0	54·8	52·3	52·7	48·2	50·3
Averages	52·6	50·6	52·0	52·8	52·8	51·0	52·6	52·9	52·7	52·8	55·1	52·6

Summary of temperature, precipitation and evaporation records at Coaldale, Brooks, Strathmore and Ronalane, showing seasonal averages for April to September, inclusive.

Station	Mean temperature 11-year period 1915–25	Precipitation 11-year period 1915–25	Evaporation 8-year period 1918–25
	Degrees F.	Inches	Inches
Coaldale	55·6	10·43	28·90
Brooks	56·6	8·32	27·70
Strathmore	52·6	11·92	24 07
Ronalane	57·0	8·31	....

Records partly obtained at Vauxhall.

Report on Drainage Surveys and Investigations

During the year 1925-26 drainage investigations were very largely confined to inspections and surveys of small schemes. The department, however, maintained supervision over the Waterhen Lake Drainage district and the McArthur Land Company's project as well as over certain provincial drainage schemes.

SMALL PROJECTS

Drainage schemes of less than 1,280 acres in area may be carried out by private interests, under the provisions of the Dominion Drainage Regulations, provided the estimated cost thereof is less than $5,000. An amendment recently made to these regulations restricts the sale of any Dominion land thereby reclaimed to the owners of the adjoining lands. All applications are investigated by engineers of the department and if the schemes are determined to be desirable and feasible, surveys are made and suitable plans prepared. The applicants are charged only with the cost of the plans.

During the year 1925-26 considerable progress has been made with these small schemes. There are some thirty-nine projects in the Edmonton district and a lesser number in the Northern Alberta district in various stages of completion, while new applications are continually being made to the department. Owing to excessive rainfall during the months of August and September a considerable amount of hay from these projects was spoiled, but it is estimated from 25,000 to 30,000 tons of feed were produced during the year on the small drainage projects in northern Alberta.

A feature of this drainage development worthy of note, particularly throughout the more northerly sections of the province, is that where schemes have been carried out, roads have been greatly improved.

Provincial Drainage Schemes

Before drainage may be undertaken under provincial drainage laws, it is necessary that authorization for the removal of the water be granted by this department. A number of schemes in the provinces of Alberta and Saskatchewan have been authorized by this department in past years. Drainage districts were subsequently organized and the works constructed.

By an amendment made recently to the Dominion Drainage Regulations it is now possible to sell to the adjoining owners at the rate of $1 per acre the reclaimed fractional quarter-sections of Dominion land included in provincial drainage districts. This is a distinct advantage to the province, to the

Dominion and to the settlers as it allows the province to collect drainage taxes on this area, brings the land into use and enables the settlers to consolidate their holdings.

The drainage works in connection with the Centre Moose Range project of the province of Saskatchewan have been completed, with the exception of a few culverts, at a cost of approximately $91,000. The East Moose Range project has been wholly completed at a cost of $40,200. The Naicam project is well under construction and to date approximately 80,000 cubic yards of earth have been excavated in the building of the canals. It is expected that the latter project will be completed next season.

In these drainage districts there is a considerable area of Dominion land which, when satisfactorily reclaimed, will be sold to the province under the provisions of the Dominion Drainage Regulations at the rate of $1 per acre, for resale by the province for the benefit of the drainage districts generally.

DOMINION PROJECTS

The lessees of the Waterhen lake unwatered lands planted 105 acres to wheat but, owing to excessive rains in June, the yield was reduced very considerably. Oats were grown by some of the lessees and cut for green feed. Eleven hundred and eighty acres of the lake bed were ploughed and double disked for seeding in 1926.

In 1923 a number of small plots were seeded to various cultivated grasses, fall rye, flax and miscellaneous crops. The grasses especially, timothy, western rye and brome, yield excellent crops and each succeeding season continued heavy yields. The fall rye located near the middle of the lake bed yielded a good crop in 1924.

During this year the major portion of the Waterhen marsh consisting of 3,388 acres, was leased to the owners of the adjoining lands for a period of ten years.

Meteorological records have been kept during the summer season of 1921-22 and 23, and for the whole year of 1924. Precipitation at Kinistino in inches during the open season of 1925 was as follows: April 1.34, May 1.19, June 5.37, July 1.96, August 5.08, September 2.47 and October 0.89.

Athabaska Drainage Project

While surveys of this project were made several years ago, the final report was completed during the past year. The area included in the Athabaska project extends from Tawatinaw creek and the Athabaska river easterly to sec. 23, tp. 67, rge. 19, W. 4th meridian, and from Pine creek northerly to the approximate divide between Pine creek and the Athabaska river. It, therefore, includes the following three main drainage outlets:—Athabaska river, Tawatinaw and Pine creeks.

The proposed system of drainage is to carry the surplus water directly to the Athabaska river wherever possible rather than to Pine creek, the capacity of which is limited. Over the greater part of the area, however, the drainage is forced by the topography to flow southerly to the extremity of the ridges where the ditches converge and lead through the natural water-courses to Pine creek. There are in all twenty main outlets or individual systems, three into the Athabaska river and the remainder into Pine creek. The proposed system requires only that each quarter section be drained by the entrant without crossing property held by others. No laterals have been provided within the quarter sections to complete the drainage, all laterals shown on plans being for the purpose of reaching the lowest point on the boundary of quarter sections not touched by the main ditch or road ditches; or to reach the areas cut off by

ridges. The improvement of Pine creek necessary to prevent increase of flood conditions would require only the removal of debris at several places and of silt and sand bars resulting from these obstructions.

The total length of ditch required is approximately 192 miles, of which 167 miles are of two foot bottom width. The remaining 25 miles of ditch will have bottom widths of three and four feet.

The constructional cost of this project has been estimated as follows:—

Right of way	$ 2,613 00
Clearing and grubbing	6,033 00
Excavation and trenching	106,324 00
Bridges, crops and gates	13,895 00
Pine Creek improvement	5,000 00
Concrete pipe and riprap	3,350 00
Engineering and contingencies	13,721 96
Total	$150,936 96

Area benefited 100 per cent	47,025.4 acres
Area benefited 50 per cent	1,673.2 "
Equivalent area benefited 100 per cent	47,862.0 "
Cost per acre	$\frac{150{,}936.96}{47{,}862} = \$3.15$	

In view of the desire of the settlers in this locality to have this scheme carried out, the province of Alberta will be furnished with full particulars of the investigation so that it will be in a position to decide whether the project should be undertaken as a provincial scheme.

CLASSIFIED LIST OF PUBLICATIONS

WATER POWER

The Reports pertaining to Water Power, published by the Dominion Water Power and Reclamation Service, with the exception of the Annual Reports, have been called Water Resources Papers, and have been numbered 1, 2, etc.

Annual Reports previous to 1913 are included with the Annual Report of the Department of the Interior, and can be secured from the secretary of the department.

Annual Reports for the fiscal years ended March 31, from 1913 to 1926, are available for distribution. That for 1924 is the first report combining the activities of the Water Power and Reclamation divisions of the Service.

REPORTS OF SPECIAL OR GENERAL INTEREST

Water Resources Paper No. 2.—Report on Bow River Power and Storage Investigations, Bow river west of Calgary, by M. C. Hendry, chief engineer in charge of surveys. This is a complete study of the Bow river west of Calgary. It deals with meteorological conditions and their effect on run-off and ice formation. Existing and possible power and storage developments, together with maps and plans are appended complete. Published 1914.

Water Resources Paper No. 3.—Report on Power and Storage Investigations, Winnipeg River, by J. T. Johnston, chief hydraulic engineer, Dominion Water Power Branch. A complete study based on field surveys and office computations of the Winnipeg River basin; deals fully with history, international considerations, topography, climate, storage possibilities; describes existing and gives preliminary designs and estimates for possible power developments; discusses other sources of power and the power market. Maps, plans and all relevant rata are appended. Published 1915.

Water Resources Paper No. 5.—Preliminary Report on the Pasquia Reclamation Project by T. H. Dunn, chief engineer in charge of Reclamation Survey. This is a progress report of investigations carried out to determine the possibility of lowering the level of Cedar lake and its effect in a general scheme for reclaiming the low-lying lands contiguous to the Saskatchewan river in the Pasquia region. Published 1914. Out of print.

Water Resources Paper No. 6.—Report on cost of various sources of power for pumping in connection with the South Saskatchewan Water Supply Diversion Project, by H. E. M. Kensit. It deals with the problem of power for pumping water from the south Saskatchewan river for the supply of cities and towns in the central portion of south Saskatchewan. Published 1914. Out of print.

Water Resources Paper No. 7.—Report on the Manitoba Water Powers, by D. L. McLean, S. S. Scovil and J. T. Johnston, compiled for the Manitoba Public Utilities Commission. A general survey of the water-power situation in Manitoba, with all available general information and hydrometric data published to date in condensed form concerning the rivers in Manitoba. Published 1914.

Water Resources Paper No. 10.—General Guide for Compilation of Water Power Reports of Dominion Water Power Branch, prepared for the guidance of field engineers of the Dominion Water Power Branch, by J. T. Johnston, chief hydraulic engineer. Published 1915. Limited edition.

Water Resources Paper No. 11.—Second Report on the Pasquia Reclamation Project, by T. H. Dunn, chief engineer in charge of Reclamation Survey. This is a continuation Report based on further investigations as outlined under Water Resources Paper No. 5. Published 1915. Out of print.

Water Resources Paper No. 12.—Report on Small Water Powers in Western Canada, and discussion on sources of power for the Farm, by A. M. Beale. Part I is a brief description of certain small western water-power developments. Part II gives an analysis of requirements and cost data for the farm power supply. Published 1915. Out of print.

Water Resources Paper No. 13.—Report on the Coquitlam-Buntzen Hydro-Electric Development. A complete description of the project and of the details of construction, with plans, diagrams and illustrations, by G. R. G. Conway, chief engineer of the British Columbia Electric Railway Company, Limited. Published 1915.

CLASSIFIED LIST OF PUBLICATIONS—Continued

Water Resources Paper No. 16.—Water Powers of Canada. A series of five pamphlets in one volume covering the water-power situation in Canada, prepared for distribution at the Panama Pacific Exposition, San Francisco, 1915, by G. R. G. Conway, consulting engineer, Toronto; Percival H. Mitchell, consulting engineer, Toronto; H. G. Acres, hydraulic engineer, Hydro-Electric Power Commission, Ontario; F. T. Kaelin, assistant chief engineer, Shawinigan Water and Power Co., Montreal; K. H. Smith, engineer, Nova Scotia Water Power Commission, Halifax, N.S. Published 1916. Out of print.

Water Resources Paper No. 17.—Canadian Hydraulic Power Development and Electric Power in Canadian Industry, by Charles H. Mitchell, consulting engineer to Dominion Water Power Branch. Part I deals with progress of utilization, features in design, construction and operation specially applicable to Canada. Description of certain typical Canadian water-power developments. Part II analyses the uses, growth and future of electrical power in Canadian industry. Published 1916. Out of print.

Water Resources Paper No. 20.—Report on the Interests Dependent on Winnipeg River Power, with Special Reference to the Capital Invested and the Labour Employed, by H. E. M. Kensit. A detailed study of the industrial growth and future power requirements of the district tributary to the Winnipeg River power sites. Published 1917. Out of print.

Water Resources Paper No. 27.—Directory of Central Electric Stations in Canada to January 1, 1919, compiled by J. T. Johnston, assistant director, Dominion Water Power Branch. Comprises an analysis of the central electric census statistics and a directory of the stations. Published 1919. Out of print.

Water Resources Paper No. 32.—Water Resources Index Inventory, by J. T. Johnston. Description of the Index Inventory System for recording and collating the water resources data of the Dominion. Published 1922. Out of print.

Water Resources Paper No. 33.—Directory of Central Electric Stations in Canada, to November 1, 1922. Comprises an analysis of the central electric station statistics and a directory of the stations. Published 1923. Price, 50 cents.

SURFACE WATER SUPPLY REPORTS

ATLANTIC DRAINAGE SOUTH OF ST. LAWRENCE RIVER, INCLUDING NOVA SCOTIA, NEW BRUNSWICK, PRINCE EDWARD ISLAND, AND SOUTHEASTERN QUEBEC

Water Resources Papers Nos. 29, 37, 45 and 52.—Surface water supply of Canada. Reports on hydrometric surveys covering the Atlantic drainage south of the St. Lawrence river, including Nova Scotia, New Brunswick, and Prince Edward Island and southeastern Quebec, for the climatic years ending September 30, 1919, 1920; 1921, 1922; 1923, 1924; and 1925, 1926, by K. H. Smith, district chief engineer. No. 52, in course of preparation.

ST. LAWRENCE AND SOUTHERN HUDSON BAY DRAINAGE IN QUEBEC

Water Resources Papers Nos. 41 and 48.—Surface water supply of Canada. Reports on hydrometric surveys covering the St. Lawrence and southern Hudson Bay drainage in Quebec, for the climatic year ending September 30, 1923, and climatic years ending September 30, 1924 and 1925, by Leo G. Denis, district chief engineer.

ST. LAWRENCE AND SOUTHERN HUDSON BAY DRAINAGE IN ONTARIO

Water Resources Papers Nos. 28, 34, 38, 42 and 49.—Surface water supply of Canada. Reports on hydrometric surveys covering the St. Lawrence and southern Hudson Bay drainage in Ontario, for the climatic years ending September 30, 1920, 1921, 1922, 1923, and 1924-25, by S. S. Scovil, district chief engineer.

ARCTIC AND WESTERN HUDSON BAY DRAINAGE (AND MISSISSIPPI DRAINAGE IN CANADA) IN ALBERTA, SASKATCHEWAN, MANITOBA, EXTREME WESTERN ONTARIO, AND NORTHWEST TERRITORIES

Water Resources Papers Nos. 4, 19, 22, 24 and 26.—Surface water supply of Canada. Reports on hydrometric surveys in Manitoba, from January 1, 1912, to September 30, 1919, by M. C. Hendry and C. H. Attwood, chief engineers. No. 4 contains a gazetteer of lakes and streams in Manitoba.

CLASSIFIED LIST OF PUBLICATIONS—Concluded

Water Supply Bulletins Nos. 1 to 11.—Surface water supply of Canada. Reports on hydrometric surveys in Alberta and Saskatchewan from 1908 to September 30, 1919, by P. M. Sauder and A. L. Ford, chief hydrometric engineers, Reclamation Service.

Water Resources Papers Nos. 31, 36, 40, 44, 46 and 50.—Surface water supply of Canada. Reports on hydrometric surveys covering the Arctic and western Hudson Bay drainage (and Mississippi drainage in Canada) in Alberta, Saskatchewan, Manitoba, extreme western Ontario and the Northwest Territories, for the climatic years ending September 30, 1920, 1921, 1922, 1923, 1924 and 1925, by C. H. Attwood and A. L. Ford, district engineers. Previous to 1919-1920 the surveys in Alberta and Saskatchewan were carried on and the results published by the Reclamation Service, Department of the Interior.

PACIFIC DRAINAGE IN BRITISH COLUMBIA AND THE YUKON TERRITORY

Water Resources Papers Nos. 1, 8, 14, 18, 21, 23, 25, 30, 35, 39, 43, 47 and 51.—Surface water supply of Canada. Reports on hydrometric surveys covering the Pacific drainage in British Columbia and the Yukon Territory from May, 1911, to September 30, 1925. No. 1 is by P. A. Carson, chief engineer, the others by R. G. Swan and C. E. Webb, district chief engineers. No. 1 contains an outline of the history of the Railway Belt with special reference to its administrative, legal and physical problems in regard to water, and a gazetteer of the lakes and streams in British Columbia.

MAP

Water Powers of the Dominion of Canada, prepared in connection with the First World Power Conference, London, Eng., 1924.

RECLAMATION

Drainage Regulations.

Irrigation Regulations.

Annual Irrigation Reports.—1894 to 1911. Out of print.

Annual Irrigation Reports.—Calendar years 1912 to 1915.

Irrigation Surveys and Inspections Reports.—Fiscal years 1915-16, 1916-17, 1917-18, 1918-19.

Annual Report of the Reclamation Service.—1919-20, 1920-21, 1921-22, 1922-23.

Annual Report of the Dominion Water Power and Reclamation Service.—1923-24, 1924-25, 1925-26.

Western Canada Irrigation Association Reports.—1st to 11th Convention, 1907 to 1917.

International Irrigation Congress Report 1914.

Bulletin No. 1.—Irrigation in Alberta and Saskatchewan. (Consisting of a Synopsis of the Irrigation Act and its Administration.)

Bulletin No. 2.—Alfalfa Culture.

Bulletin No. 3.—Climatic and Soil Conditions, C.P.R. Irrigation Block.

Bulletin No. 4.—Duty of Water Experiments and Farm Demonstration Work.

Bulletin No. 5.—Farm Water Supply.

Bulletin No. 6.—Irrigation Practice and Water Requirements for Crops in Alberta.

Pamphlets:

- Address by Mr. S. G. Porter—"Practical Operation of Irrigation Works."—Extract from W.C.I.A. Report, 1924.
- Address by Dr. Rutherford—"Inter-dependence of Farm and City."—Extract from W.C.I.A. Report, 1914.
- Address by Mr. Don. H. Bark—"The Actual Problem that Confronts the Irrigator."—Extract from W.C.I.A. Report, 1914.
- Address by Mr. Don. H. Bark—"Practical Irrigation Hints for Alberta."—Extract from W.C.I.A. Report, 1915.
- Address by Mr. Don. H. Bark—"Alfalfa Growing."—Extract from W.C.I.A. Report, 1915
- "Practical Information for Beginners in Irrigation" (by W. H. Snelson, A.M.E.I.C.).

Water Resources Papers, and Irrigation and Drainage Reports, as listed at the end of this report are issued gratis, with the exception of Water Resources Paper No. 33, for which a charge of 50 cents is made. These can be had on application to the Director of Dominion Water Power and Reclamation Service, Department of the Interior, Ottawa.

DEPARTMENT OF THE INTERIOR, CANADA

HON. CHARLES STEWART, Minister; W. W. CORY, C.M.G., Deputy Minister

DOMINION WATER POWER AND RECLAMATION SERVICE

J. T. JOHNSTON, C.E., Director

ANNUAL REPORT

1926-27

OTTAWA
F. A. ACLAND
PRINTER TO THE KING'S MOST EXCELLENT MAJESTY
1928

DEPARTMENT OF THE INTERIOR, CANADA
HON. CHARLES STEWART, Minister; W. W. CORY, C.M.G., Deputy Minister

DOMINION WATER POWER AND RECLAMATION SERVICE
J. T. JOHNSTON, C.E., Director

ANNUAL REPORT

OF THE

DOMINION WATER POWER

AND

RECLAMATION SERVICE

FOR THE

Fiscal Year Ending March 31, 1927

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WATER POWER AND RECLAMATION

INTRODUCTORY

On August 1, 1926, Mr. S. S. Scovil, Assistant Director of the Dominion Water Power and Reclamation Service, resigned to engage in private practice as consulting engineer and Mr. V. Meek was promoted to fill the vacancy thus created.

ORGANIZATION

International Waterway Matters.—The organization of the Dominion Water Power and Reclamation Service in field and office is such as to facilitate the ready compilation and analysis of run-off and other hydrometric and hydraulic data on boundary waters and on waters flowing into boundary waters along the international boundary between Canada and the United States. Because of its facilities the service has been charged with the responsibility of securing such data and of making such studies as are necessary for an intelligent consideration of all matters affecting boundary waters, and of advising the minister with respect thereto.

Water-power.—The water-power activities are both administrative and investigatory. The proprietary interest of the Dominion in the water resources of Alberta, Saskatchewan and Manitoba, of the Northwest and Yukon Territories and of the Railway Belt in British Columbia gives rise to the necessity of administering these resources in accordance with the Dominion Water Power Act and the Regulations thereunder, and places upon this service the responsibility of securing such fundamental engineering and economic data as will enable it to control properly the development, distribution and sale of hydro-electric energy.

Throughout the rest of Canada the water-powers are vested in the provinces, and investigatory work is carried on in co-operation with the respective provincial authorities charged with the administration of these resources. The service also co-operates extensively with federal departments and commissions other than the Department of the Interior, making the services of its field engineering staff available to these organizations, when, in the interests of general economy and efficiency, it is desirable to do so.

The co-operative water-power and hydrometric survey work is undertaken through district offices, each in charge of a district chief engineer, located as follows: British Columbia, at 739 Hastings Street west, Vancouver; Alberta and Saskatchewan, at Southam Chambers, Calgary; Manitoba, at 706 Commercial Building, Winnipeg; Ontario, the local organization has headquarters at the Ottawa office of the service; Quebec, at 201 Inspector street, Montreal; The Maritime Provinces, at 193 Hollis street, Halifax. In every case the district offices are operated in the closest co-operation with the provincial offices engaged in the administration or use of water or water-power.

In the Yukon and Northwest Territories the water-power resources are administered from Ottawa, and, in the case of the Yukon, through the Gold Commissioner at Dawson. Investigatory work in the Yukon is handled through the British Columbia organization and in the Northwest Territories as the exigencies of the situation demand.

The water-power field organization is based upon and built up around the Dominion Hydrometric Survey staff, through which systematic and continuous

stream measurement studies are carried on throughout the Dominion. The data secured by the hydrometric staff and through the co-operative efforts of the various provincial and other organizations are collated, analyzed and standardized at the head office of the service at Ottawa, with the result that there is already available in Ottawa both general and detailed information concerning the run-off and power possibilities of the more important power rivers throughout Canada. These data are constantly being revised as new or later information is received and are promptly available for reference to all interested in the utilization of the water-powers of the Dominion.

Irrigation and Drainage.—The surface waters in the provinces of Alberta, Saskatchewan, northern Manitoba and the Northwest Territories are administered by the federal Government under the Irrigation Act. All matters that affect the control of water supply generally, as well as the inspection and authorization of works for the use of water for domestic, municipal, industrial and irrigation purposes and the granting of license for such purposes are dealt with thereunder. Every endeavour is made to administer the water supply so that the greatest benefit may result to the public. The Commissioner of Irrigation at Calgary, Alberta, is responsible for all field administration.

The Reclamation Act and Regulations having to do with the reclamation of lands by drainage are administered along similar lines. Any questions of drainage affecting federal interests in the provinces of Manitoba and British Columbia to which the Irrigation Act does not apply, are dealt with through the agency of the district chief engineers of this service in those provinces. Close co-operation is at all times maintained with the provincial drainage authorities.

PUBLICATIONS

A list of the Annual Reports, Water Resources Papers and Reclamation Reports published to date will be found at the end of this report, and copies of those which are still in print will be sent on application to those interested, free of charge, except in the case of the Directory of Central Electric Stations in Canada, for which a charge of fifty cents is made.

During the past year the Annual Report for the fiscal year 1924-25 and Water Resources Papers Nos. 46, 48, 49, 51 and 56 were published. The Annual Report for the fiscal year 1925-26 and Water Resources Paper No. 50 are now in press. Bulletins were issued dealing with Hydro-Electric Progress in Canada during 1926 and the Water Power Resources of Canada as at March 1, 1927.

PART I

INTERNATIONAL WATERWAY MATTERS

During the year International Waterway problems continued to receive close consideration, and appropriate action was taken from time to time in connection with the various matters arising.

In October, following an exchange of correspondence with the United States Government, the International Niagara Board of Control was enlarged and made responsible for the determination as to how the scenic beauty of Niagara falls and rapids can best be maintained and by what means and to what extent the impairment thereof by erosion or otherwise can be overcome, and, consistent with the preservation of the scenic beauty of the falls and river, for the determination of what quantity of water might be diverted from the river for power purposes. Since its appointment the board has been systematically engaged in the compilation and study of the basic data upon which its conclusions must necessarily be founded. While some considerable time must elapse before the board will be in a position to formulate its views, a great proportion of the preliminary work is well under way.

The suit between the complainant States of Wisconsin, Minnesota, Pennsylvania and Ohio vs. the Chicago Sanitary District, before the United States Supreme Court, in reference to the diversion of water from the Great Lakes System to the Mississippi watershed, involves legal principles of the very highest importance to Canada, and its progress is being followed with the utmost care, in order that the effect on Canadian interests of whatever decision is reached may be fully appreciated and that any necessary action may be taken to protect those interests.

Following the execution of the Lake of the Woods Convention between Canada and the United States on February 24, 1925, a number of the provisions embodied therein are now involving the attention of the department. One of these provisions calls for the establishment and maintenance of an International Lake of the Woods Control Board, composed of two engineers, one appointed by the Government of Canada and one by the Government of the United States, from their respective public services. Whenever the level of the lake rises above elevation 1061 or falls below elevation 1056 sea-level datum, the rate of total discharge of the water from the lake shall be subject to the approval of this board. The International Board is designed to work in conjunction with a Canadian Lake of the Woods Control Board also provided for by the convention, composed of engineers and responsible for the regulation and control of the outflow of the waters of lake of the Woods when between the above named elevations.

The International Board was formally constituted in October last, the Director of this service being appointed as member for Canada. The International Board has not, as yet, found it necessary to exercise its functions as the lake has been maintained well within the treaty limitations by the Canadian board. The preparation of the final plans showing the reconstruction of the Norman dam and the enlargement of the western outlet of the lake of the Woods, in conformity with the requirements of the convention, is under way for formal submission to an approval by the International Board.

Incorporated in the Lake of the Woods Convention is the Rainy Lake Reference to the International Joint Commission, which has to do with the provision of storage in Rainy lake and in the boundary waters above, and with the development of power in connection therewith. Intensive field and office investigatory work in connection with this Reference has been under way during the year and excellent progress has been made. These investigations will be continued during the forthcoming season.

Other international waterway issues have been raised such as those in connection with the Columbia River reclamation project in the United States and its effect on the Pend d'Oreille river in British Columbia; the Kootenay Flats reclamation project on the Kootenay river where it crosses the boundary in British Columbia; the problem of flooding on the Roseau river due to construction of drainage works on the United States side of the border; the alleged pollution of boundary waters on the Similkameen and Moyie rivers in British Columbia; and the alleged harmful effects on lake levels of dredging operations in the St. Clair and Niagara rivers.

The various international waterway boards have functioned as usual throughout the year.

In accordance with the rulings of the International Joint Commission made on October 4, 1921, in conformity with the Boundary Waters Treaty of 1909, the measurement and apportionment of the stream flow in the St. Mary and Milk rivers and their tributaries in the province of Alberta and Saskatchewan and in the state of Montana, were continued throughout the past year by an engineer of this service, in co-operation with an engineer of the United States Reclamation Service. The report covering the year's operation has been prepared and submitted to the commission for review upon the occasion of its regular semiannual meeting in April.

In the face of the abnormally low water conditions with which it has been confronted, the policy of the International Lake Superior Board of Control has been to conserve the Lake Superior inflow, in so far as possible, and at the same time keep in mind the overall interests of navigation by releasing any water which might, in the light of all circumstances, be spared for the betterment of navigable conditions in the channels below. The precipitation records available for the first half of 1926 indicate that the rainfall in the Superior basin was still deficient and that there was at that time little prospect of any material increase into lake Superior during the summer. Beginning with the month of June, however, the precipitation records showed a marked improvement and for each month to the end of the navigation season, the precipitation was somewhat greater than the mean of the period 1872 to 1925. As a result of the betterment in precipitation, the lake levels are showing a gradual improvement.

The International Niagara Board of Control has continued its close regulation of the diversions from Niagara river for power purposes as permitted by Article V of the Boundary Waters Treaty. Continuous records of the withdrawal of water by all power stations on both sides of the river are obtained by the board and the control exercised is such as to ensure that the limits of diversion set forth in the treaty are not exceeded.

Conditions obtaining with respect to the submerged weir in the South Sault channel of the St. Lawrence river, and the regulation of flow through the Massena canal were subject to the supervision of the International Massena Board of Control throughout the year, in accordance with the order of the International Joint Commission dated December 6, 1922. No abnormal conditions developed during the year. The reconstruction work along the Cornwall canal which has been under way in accordance with the terms and conditions of the agreement entered into between the St. Lawrence River Power Company and His Majesty, as represented by the Dominion Department of Railways and Canals, which agreement had received the endorsement of the Board of Control, has been completed and has received the board's approval.

The International St. Croix River Board of Control continued to exercise its supervision over the discharge of the St. Croix river past the Grand Falls dam in accordance with the orders of the International Joint Commission dated November 9, 1915, and October 3, 1923. No abnormal conditions developed during the year and the systematic records obtained by the board indicate that a satisfactory flow of water has been maintained in the river below the dam for the benefit of power users and for the supply of water for the fishways.

PART II

WATER-POWER

LAKE OF THE WOODS CONTROL BOARD

The Lake of the Woods Control Board was, as in previous years, responsible for the regulation of the levels and outflow of lake of the Woods.

This regulation embraces, among other things, the continuous collection of hydrological data relating to the watershed, and in this connection the board was, as previously, indebted to the Department of Public Works for run-off records on Rainy and Namakan lakes, and to the Dominion Meteorological Service and the United States Meteorological Service for precipitation records at numerous stations throughout the watershed. Lake of the Woods level was at elevation 1059.65 on April 1, 1926, and as the precipitation over the watershed throughout the year was above normal it was necessary to maintain comparatively high outflow throughout the year in order to keep the level of the lake below the upper storage limit.

The reconstruction of the Norman dam was completed in the month of May and with the installation of a second stoplog winch for the sluices in the southern end of the dam proper and efficient control of level and outflow, in accord with treaty stipulations with the Government of the United States, will be possible and protection will be assured for the domestic water supply and power requirements of Winnipeg, Kenora, and the surrounding districts.

On February 21, 1927, the following Orders in Council affecting the board were passed:—

P.C. 248 Order in Council authorizing the appointment of Mr. T. H. Hogg, Chief Hydraulic Engineer of the Hydro-Electric Power Commission of Ontario, as an alternative member of the Lake of the Woods Control Board with Mr. H. G. Acres.

P.C. 249 Order in Council authorizing the Lake of the Woods Control Board to gather and co-ordinate through existing governmental agencies, all information necessary to a consideration of the Rainy Lake Reference and to make such recommendations as it may consider advisable for the protection of Canadian interests in the international matters at issue.

WATER-POWER REGULATIONS AND LEGAL RESEARCH

The Dominion Water-Power Regulations have not been amended during the past year and no new rights have been granted under them.

The study of Dominion and provincial legislation and jurisprudence relating to the uses of water has been continued, more particularly as these bear upon water-power administration. The work in this connection during the past year was confined chiefly to the water-power laws of Ontario and Quebec and has proved of value in many of the questions with which this service has to deal.

In connection with the administration of international boundary waters, a study of the treaty provisions governing their use for power and other purposes is being made and a large amount of material bearing upon this subject has been examined and collated.

BRITISH COLUMBIA ADMINISTRATION

Since 1912 the waters in the Railway Belt of British Columbia which, together with the ungranted Crown lands therein, belong to the Dominion, have been administered by the province under the provincial water acts, as provided by the Railway Belt Water Act. Water privileges granted by the province in the Railway Belt are examined in this department for the due protection of Dominion interests, and rights in Dominion lands required in the exercise of these privileges are granted as required.

The Railway Belt Water Act was amended in 1926 to make the most recent provincial water acts applicable to the Railway Belt, to quiet any titles to water rights previously granted by the province as to which doubts might arise and to make clear the rights of the Dominion with regard to the protection of Dominion interests. Some further changes in the Act to meet the wishes of the provincial authorities are proposed, and it is expected that these will shortly be enacted.

The examination of water records appurtenant to Indian reserves throughout the province, and the preparation of evidence in support of Indian claims to water rights, have been continued by the local engineering staff of this service and is now almost completed, as practically all the Indian claims have been dealt with by the Board of Investigation under the Water Act, and licenses issued in place of the former records.

ENGINEERING CO-OPERATION WITH INDIAN DEPARTMENT

At the request of the Indian Department, the District Chief Engineer at Winnipeg prepared reports on the improvement of the water supply systems at the Sioux Lookout Indian school in Ontario and at the Fort Alexander Indian school on lake Winnipeg. This is referred to more fully in the report of the District Chief Engineer for Manitoba.

The local engineering staff of the service in British Columbia has also conducted a number of investigations on behalf of the Department of Indian Affairs for the improvement of irrigation conditions on Indian reserves and to provide increased amenities for the Indians, and a considerable amount of construction has been carried out under the supervision of these local officers, in particular a pumping irrigation plant at Kamloops industrial school, a water supply system for the village of Bella Coola and an electric lighting system for the village at Squirrel Cove. These matters are discussed more fully in the report of the District Chief Engineer for British Columbia.

WATER RESOURCES INDEX INVENTORY

The Index Inventory system for recording and collating the water resources data of the Dominion has been in actual use for a number of years and has provided a most efficient method for the referencing, analysis, standardization and filing of all data relating to the subject of water resources. A detailed description of the system has appeared in the Annual Report for 1916-17 and in the combined reports for the years 1917-18-19.

The system has been applied to practically all phases of the work carried on by the service, among the more outstanding of which may be mentioned the complete census of developed water-power, the analysis of central electric station activities, undeveloped water-power resources, stream measurement activities and storage investigations.

This work has been largely carried on in co-operation with provincial organizations, notably the Hydro-Electric Power Commission of Ontario, the Quebec Streams Commission, the British Columbia Water Rights Branch, the Nova Scotia Power Commission and the New Brunswick Electric Power Commission. The data compiled are being continually revised in accordance with the most up-to-date information and, resulting from a number of years of effort, a very large amount of information in standardized form is now available.

WATER-POWER RESOURCES OF CANADA

The steady consistent growth of hydraulic installation emphasizes the necessity and importance of an annual inventory of our water-power resources in order that accurate information as to the total available and developed water-power of the country may be available.

By the end of the year 1926 Canada's hydraulic installation reached a total of 4,556,266 h.-p., of which 265,838 h.-p. was installed during that year. While the addition for 1926 was substantial, it falls far short of indicating actual constructional activities as projects under way, a number of which are nearing completion, will ultimately add to the Dominion's total more than 1,700,000 h.-p., while others in active prospect indicate a further addition of 1,000,000 h.-p. As the capital investment due to these developments under construction and in prospect is estimated at approximately $270,000,000, regardless of the extra capital required in the application of their power output, some idea is gained of the stimulus which will be given industry by their completion.

Complete information regarding Canada's great water-power resources is not yet available but all existing stream-flow and power data from federal, provincial and private sources have been systematically collated, analysed and co-ordinated with the object of presenting a dependable estimate of available power based on uniform methods of computation and arrangement.

BASIS OF COMPUTATION

The figures for available water-power listed in table 1 are based upon rapids, falls and power sites of which the actual existent drop or the head possible of concentration, is definitely established or at least well authenticated. Many rapids and falls of greater or lesser power capacity are scattered on rivers and streams from coast to coast which are not as yet recorded, and which will only become available for tabulation as more detailed survey work is undertaken and completed. This is particularly true in the relatively unexplored northern districts. Nor is any consideration given to the power concentrations which are feasible on rivers and streams of gradual gradient, where economic heads may be created by the construction of power dams, excepting only at such points as definite studies have been carried out and the results made matters of record.

In brief, the figures hereunder are based on definite rapids, falls and power sites, and may be said to represent the *minimum water-power possibilities of the Dominion.*

The power estimates have been calculated on the basis of 24-hour power at 80 per cent efficiency for conditions of "Ordinary Minimum Flow" and "Ordinary Six Months Flow". The "Ordinary Minimum Flow" is based on the averages of the flows for the two lowest periods of seven consecutive days in each year, over the period for which records are available. The "Ordinary Six Months Flow" is based upon the continuous power indicated by the flow of the stream

for six months in the year. The actual method to determine this flow is to arrange the month of each year according to the day of the lowest flow in each. The lowest of the six high months is taken as the basic month. The average flow of the lowest seven consecutive days in this month determines the ordinary six-months flow for that year. The average of such figures for all years in the period for which data are available is the ordinary month's flow used in the calculation.

Estimates of power on the basis of ordinary six-months flow are made upon the assumption that it is good commercial practice to develop wheel installation up to an amount, the continued operation of which can be assured during six months of the year, with the deficiency in power during the remainder of the year provided from storage not yet created or by the installation of fuel power plants as auxiliaries. The correctness or otherwise of this assumption for any particular site can only be definitely settled by careful consideration of all circumstances and conditions pertinent to its development. The method, however, enables a fairly satisfactory over-all estimate of the maximum hydraulic power available to be made as distinctive from the estimated ordinary minimum power available.

AVAILABLE AND DEVELOPED TOTALS

The known available water-power in Canada, from all sources and within the limitations outlined, is 18,255,000 h.-p. for conditions of ordinary minimum flow and 32,076,000 h.-p. ordinarily available for six months of the year.

It is believed that these are conservative estimates since an analysis of the water-power plants scattered from coast to coast concerning which complete data are available as to turbine installation and satisfactory information as to stream-flow, gives an average machine installation 30 per cent greater than the ordinary six-months flow power. Applying this, the figures quoted above, therefore, indicate that the present *recorded water-power resources* of the Dominion will permit of a turbine installation of 41,700,000 h.-p.

The total installation to date in water wheels and turbines throughout the Dominion is 4,556,266 h.-p. In other words the present turbine installation represents *less than 11 per cent* of the recorded water-power resources.

CURRENT PROGRESS IN DEVELOPMENT

A year of widespread activity in the field of hydro-electric and water-power development in Canada is again evident from the following review prepared by this service. While the total additional installation throughout the Dominion did not reach the record figure of the preceding year, it was nevertheless substantial, being just slightly under 266,000 h.-p., which brings the total installation in Canada to 4,556,000 h.-p.

In the review of activities by provinces, which follows, it will be noted that Quebec took the lead in 1926 with 168,000 h.-p., followed by British Columbia with 45,800 h.-p., Manitoba with 43,200 h.-p., Ontario with 5,700 h.-p., New Brunswick with 2,600 h.-p., and a small addition in Nova Scotia. The small addition in Ontario is largely attributable to the completion, in 1925, of a very large program of construction which had extended over several years and as a result a certain period of time must elapse before new projects commence to add their quota to the provinces' total. The outstanding achievement of the year was undoubtedly the work accomplished by the Gatineau Power Company in the virtual completion of its two plants on the Gatineau river at Chelsea, P.Q.

and Farmers rapids, P.Q., and the initiation of construction at Paugan falls, P.Q., these three plants having a total designed capacity of 530,000 h.-p. Other works of magnitude were carried out by the Powell River Company and the West Kootenay Power and Light Company in British Columbia; the Manitoba Power Company and the city of Winnipeg in Manitoba, the Ontario Hydro-Electric Power Commission and the Quinte and Trent Valley Power Company in Ontario; the Duke-Price Power Company, the North Shore Power Company, the Canadian International Paper Company and the Ontario Paper Company in Quebec, while in New Brunswick work was commenced by the St. John River Power Company at Grand Falls on the St. John river.

British Columbia.—The total increase of 45,860 h.-p. in the installation in British Columbia was contributed by the West Kootenay Light and Power Company at Lower Bonnington Falls and the Powell River Company in its plant at Powell River.

The West Kootenay Light and Power Company completed its 60,000-hp. plant at Lower Bonnington falls on the Kootenay river by the addition of the third unit of 20,000 h.-p. Preliminary work was also carried out by the same company in connection with a new development of 60,000 h.-p. at South Slocan. This work will be actively prosecuted during 1927.

The Powell River Company completed an extensive program of construction in connection with its pulp and paper mill and power plant at Powell River on the lower coast. In addition to replacing some of the old generating machinery with new, a new hydro-electric unit of 13,500 h.-p. was installed, together with two 6,180-hp. units direct connected to pulp grinders, making in all an addition of 25,860 h.-p.

The British Columbia Electric Railway Company completed the Alouette dam and spillway early in the year and the resulting water storage proved of the greatest benefit during the low-water season of 1926 in augmenting the supply at the Stave Falls power station. The construction of the 12,500-hp. Alouette power station is being proceeded with, and is to be completed in 1927. In connection with the Bridge River project, the company carried on engineering investigations and at the site of the power station on Seton lake, extensive work was done in the preparation of camp buildings, tracks and material yards. It is anticipated that a contract for the main tunnel, 14,000 feet in length will be awarded by midsummer of 1927. This project is designed for an initial capacity of 54,000 h.-p. and may ultimately reach a total of from 550,000 to 700,000 h.-p. At Jordan river on Vancouver island the company raised its storage dam eight feet and has commenced the construction of a new flume of larger capacity than the one now in use.

Among rivers on which hydro-electric projects have been under investigation may be mentioned the Campbell, Shuswap, Cheakamus, Upper Columbia and Kettle.

Alberta.—In Alberta, although no new installations were added during the year, the Calgary Power Company extended its transmission system south a distance of 35 miles to serve the town of High River and a further extension of 12 miles to the town of Blackie. Power will be supplied from the company's plants on the Bow river at Seebe.

Manitoba.—In Manitoba additions totalling 43,200 h.-p. were made to the plants of the city of Winnipeg and the Manitoba Power Company.

The city of Winnipeg added units 15 and 16 to its station at Point du Bois on the Winnipeg river. These units which are each of a capacity of 7,600 h.-p. complete the installation of the Point du Bois station which now has a capacity of 109,000 h.-p.

At the Great Falls plant of the Manitoba Power Company on the Winnipeg river, unit number three of 28,000-hp. capacity was added bringing this station to a total of 84,000 h.-p. A contract for the fourth unit also of 28,000-hp. capacity has recently been let for installation in 1927. In addition to this new power installation the company has completed the structures appurtenant to the power station which will permit raising the forebay level to secure the full designed head. A steel tower 110,000 volt, transmission line was also built from Great Falls to the mill of the Manitoba Paper Company near Fort Alexander. This line will eventually form part of a new transmission line from the Great Falls plant to Winnipeg. It is also proposed to build a line from Great Falls to the Rice Lake mining district which lies to the northeast.

To provide for its further needs when the Point du Bois plant is fully loaded the city of Winnipeg has entered into a ten-year contract with the Manitoba Power Company where the company will supply the city with a block of power starting with 10,000 h.-p. in 1928 and reaching a maximum of 30,000 h.-p. two years later, the price to be $17.50 per year per horse-power maximum demand.

During the year the Manitoba Power Commission added to its system by the construction of a line from Portage la Prairie to High Bluff, a distance of 8½ miles.

Ontario.—The new installation in Ontario during 1926 was comparatively small amounting to 5,746 h.-p. but other works which are under construction or in early prospect will add considerably to the provincial total.

The Ontario Hydro-Electric Power Commission brought to completion at the close of 1925 its two large stations, the Queenston, on the Niagara river, with 550,000 h.-p. and the Cameron Falls, on the Nipigon river, with 75,000 h.-p. The Queenston station is now fully loaded and for the further supply of the Niagara system the commission has entered into a contract with the Gatineau Power Company for a block of from 230,000 to 260,000 h.-p., delivery to commence in 1928. This power will be supplied from stations now under construction on the Gatineau river in the province of Quebec and the energy will be carried over a high tension transmission line from the plants direct to Toronto. Surveys for the line are practically completed and construction will commence during 1927. On the Nipigon river the commission has commenced the construction of a new plant of 54,000-hp. capacity at Alexander Landing, a short distance below the Cameron Falls station. Power from this new station will feed the Thunder Bay system and supply the growing market in the Port Arthur and Fort William district. In the Georgian Bay system the commission completed the construction of a plant of 1,550-h.p. capacity at Hanna chute on the South Muskoka river a short distance above and connected with the South Falls station.

In the Trent valley the Quinte and Trent Valley Power Company completed two developments, one at Campbellford with 1,100 h.-p. and the second at Frankford with 2,980 h.-p., the power being used in those localities.

In Northern Ontario the Abitibi Power and Paper Company completed the transmission line from its 48,000-hp. plant at Island Falls on the Abitibi river to the mills at Iroquois falls, and energy was delivered during the year. The town of Cochrane is also served from this line. A short distance to the west the Spruce Falls Company commenced the construction of a development at Smoky falls on the Mattagami river which will probably have an installation of 70,000 h.-p. and will supply energy to the company's pulp and paper mills in the district.

In the extreme westerly part of the province the Keewatin Power Company completed its 17,000-hp. development at the western outlet of the lake of the Woods. In the same district the Backus Brooks Company commenced the con-

struction of three developments on the Seine river which will have a total capacity of 37,620 h.-p. Two of these plants are well advanced and all are to be completed during 1927. The power will be transmitted to Fort Frances for use in the pulp and paper mills at that place.

Quebec.—Water-power activities in Quebec province continued on a large scale during 1926 and, while the total of some 168,000 h.-p. actually placed in operation fell short of that of the record year 1925, developments now under construction represent a future addition of more than 1,400,000 h.-p., which indicates that progress has not slackened.

The hydro-electric activities of the Canadian International Paper Company in the Hull district are outstanding among the year's developments. The company started construction of a large electrically driven pulp and paper mill at Gatineau, Quebec, a short distance east of Hull, and through its subsidiary, the Gatineau Power Company, of three important hydro-electric developments on the Gatineau river, namely, 120,000 h.-p. at Farmer's Rapids, 170,000 h.-p. at Chelsea, and 240,000 h.-p. at Paugan Falls. The first two plants are practically completed, the first unit being placed in operation at the beginning of 1927, while work on the Paugan plant has been recently commenced. These plants are to supply the company's pulp and paper mill and, as previously mentioned, a large block is to go to the Niagara system of the Ontario Hydro-Electric Power Commission. This company is also taking an active part in the construction of the Baskatong storage reservoir on the Gatineau river under the direction of the Quebec Streams Commission.

In the Lake St. John district the Duke-Price Power Company has added two units of 45,000 h.-p. each to the Ile Maligne development on the Saguenay river; the present installation now totals 450,000 h.-p. while the ultimate capacity is to be 540,000 h.-p. Preliminary construction is being continued on the 800,000-hp. development of the Aluminum Company of Canada at Chute-a-Caron on the Saguenay. A very notable feature of this district has been the establishment of new industries attracted by the remarkable power facilities offered by these most advantageous sites. The Aluminum Company is already operating its reduction works at the new town of Arvida, while a number of large pulp and paper mills and a $12,000,000 electro-metallurgical plant are either under construction or projected. The construction of a 168,000-volt transmission line is well under way to connect the Duke-Price Power plant with the Shawinigan system at Quebec city.

The Shawinigan Water and Power Company through its subsidiary the North Shore Power Company, placed in operation a new development of 22,200 h.-p. at St. Narcisse on the Bastican river, replacing a 1,600-hp. installation reputed to be the first in the British Empire to supply energy over long-distance transmission.

Other hydraulic installations placed in operation during the year include a 16,800-hp. addition to the Kipawa plant of the Canadian International Paper Company; the addition of 800 h.-p. to the Pont Rouge plant of the Donnaconna Paper Company; a 2,000-hp. addition to the Electric Reduction Company's plant at Buckingham; a new development of 515 h.-p. on the Little Blanche river by the Papineauville Lumber Company and a 72-hp. plant at Mastai in connection with hospital work.

A fifty-mile transmission line has just been completed from the Quinze power plant of the Canada Northern Power Company to supply the Rouyn mining field of northern Quebec. A fairly extensive rural electric supply system has also been completed on the island of Orleans by the Montmorency Electric Company, the energy being secured from the Quebec Power Company.

The Ontario Paper Company has under construction a 40,000-hp. development on the Outardes river and installed a unit of 1,300 h.-p. during 1926 to supply power for construction purposes.

At St. Alban on the Ste. Anne-de-la-Pérade river the Shawinigan Water and Power Company has started the construction of a 4,000-hp. development which replaces an older installation of 750 h.-p. at that place.

The town of Coaticook has almost completed a 2,000-hp. plant within the town on the Coaticook river replacing four smaller installations which aggregated 570 h.-p.

In the Laurentian district north of Montreal the Quebec Southern Power Corporation has acquired the St. Jerome municipal plant and is increasing the installation of its Rawdon plant from 300 h.-p. to 2,500 h.-p., the ultimate installation to be 7,500 h.-p. The corporation has also added 100 miles of transmission lines to its system, which now totals 270 miles.

Other additions which are practically completed include improvements to the Montreal Cotton Company's plant at Valleyfield to increase its capacity to 12,000 h.-p. and 1,200 h.-p. added to the Paton woollen mill at Sherbrooke.

Projects which are under active consideration include a 65,000-hp. development on the Prairie river near Montreal by the Power Corporation of Canada, a 50,000-hp. development at Spicer Fall on the St. François river by the Southern Canada Power Company, a new or additional installation of from 4,000 to 9,000 h.-p. by the Donnacona Paper Company on the Jacques Cartier river; the development of 3,000 h.-p. at the Westbury site on the St. François river by the city of Sherbrooke; a 40,000-hp. plant at Mountain Fall on the Rouge river by the Canadian International Paper Company; 16,000 h.-p. on Mille Isles river near Terrebonne to supply a pulp mill; a 50,000-hp. addition to the Ottawa River Power Company's plant at Bryson on the Ottawa river; the distant possibility of a 10,000 to 20,000-hp. plant on Mistassini river in connection with the Mistassini Pulp and Power Company's paper mill, which for the present, may be supplied with power from the Duke-Price Power Company; and a possible development of several thousand horse-power from Ste. Ursule falls on the Maskinonge river.

The Quebec Streams Commission continued its beneficial work which so enhances and encourages water-power development throughout the province. The commission now has extensive storage reservoirs in operation on the St. Maurice and the St. François rivers, Kenogami lake, Ste. Anne-de-Beaupré and Métis rivers, all of which are at present reported filled to capacity, the various plants affected being assured of an ample supply of water during the winter of 1926-27. The commission now has under its supervision the construction of the Baskatong reservoir on the Gatineau river, expected to be completed before the end of the winter season, this includes Baskatong lake and is to have a capacity of ninety-four billion cubic feet to regulate the flow to 8,000 cubic feet per second. The existing storage system on the North river comprising three lakes was also recently taken over by the commission with the intention of improving the same in the near future. Further studies were made of the Mekinac storage on the lower St. Maurice including additional borings and it has now been decided to proceed with construction this spring at a cost of some $600,000. Other work includes storage surveys on the Batiscan River basin; a summary investigation of the Megiscan watershed for power and storage, a power site investigation on Rimouski river and a storage reservoir survey on Sud river.

New Brunswick.—The net increase of 2,600 h.-p. in the total installation in New Brunswick was accounted for in the plant of the Maine and New Brunswick Electrical Power Company at Aroostook Falls on the Aroostook river. This was occasioned by the replacement of a unit in the plant by one of larger capacity.

Of outstanding importance was the initiation of work at Grand Falls on the St. John river. At this site, which is the largest in the Maritime Provinces, actual development was commenced during the month of August by the St. John River Power Company. The scheme calls for an initial installation of 60,000 h.-p. in three units of 20,000 h.-p. each and involves the erection of a dam just above the falls, a tunnel through the rock under the town and a power-house in the lower basin which will operate under a head of 130 feet. The power will be used principally in news print mills to be erected by the New Brunswick International Paper Company and the Fraser Companies Limited. In addition a block of power has been reserved for the New Brunswick Electric Power Commission.

The New Brunswick Electric Power Commission has built a new concrete dam at loch Alva in connection with its Musquash development. In connection also with the Musquash system a transmission line was built from Moncton to Shediac and another line of 35 miles is about to be built to Blacks Harbour. The commission is at present carrying out an investigation of the power site known as Meductic Falls on the St. John river about forty miles above Fredericton.

The Bathurst Company Limited has made investigations on the Nipisiguit river with respect to both power and storage which may ultimately result in the development of some 40,000 h.-p. for use in the company's pulp and paper mills.

Nova Scotia.—In Nova Scotia the Nova Scotia Power Commission has added a unit of 300 h.-p. to its Mushamush development and is negotiating with the town of Mahone to take over the town's plant. The commission is building two new storage dams on the East River Sheet Harbour and is co-operating with the Pictou County Board in the construction of a transmission line from Stellarton to serve the communities of Eureka and Hopewell.

On Mulgrave brook a small plant of 75 h.-p. was put into operation to serve the needs of the town of Mulgrave.

The Digby County Power Board has under construction a hydro-electric plant of 330 h.-p. at the upper falls on the Sissiboo river from which a transmission line of 32 miles will deliver power to the towns of Weymouth, Digby and Smith's Cove.

Prospective developments in the province include the Sandy Lake stage of the St. Margaret Bay development for the Nova Scotia Power Commission to meet the growing load in Halifax; a development on the Medway river by the commission for the initial supply of about 2,500 h.-p. to the Scott Paper Company for a ground wood mill; a development of 3,000 h.-p. at Avon River Falls for the Avon River Power Company and a further development on the west branch of the Tusket river to supply the town of Yarmouth.

Investigations have also been made of the power possibilities of the Gaspereau river which will yield some 9,000 h.-p. and the St. Croix river which has a capacity of from 4,000 to 5,000 continuous h.-p.

UTILIZATION OF DEVELOPED WATER-POWER

A study of the uses to which the 4,556,266 h.-p., the present hydraulic installation of Canada, are apportioned, is shown in table 2 and serves to emphasize the comment already made on the growing importance of the distribution of hydro-electricity through the medium of central electric stations, 3,685,428 h.-p. or 80·9 per cent of the total being installed for that purpose.

Pulp and paper mills maintain a hydraulic installation of 526,731 h.-p. or 11·6 per cent of the total and in addition are very large purchasers of hydro-electricity from the central stations referred to in the previous paragraph. It

is estimated that the electrical output from approximately 425,000 h.-p. of the central station installation is so purchased, giving a total utilization of hydro-electricity for the manufacture of pulp and paper of over 951,000 h.-p.

General industrial enterprises such as electro-chemical reduction, lumber manufacturing, flour milling, grain grinding, water pumping, etc., employ 344,107 h.-p. or 7·5 per cent of the total.

Column 7 of table 2 shows the total hydraulic installation per 1,000 of population and when it is realized that commercial prosperity is largely dependent upon increasing the output of the workers through the greater use of mechanical power Canada's high average of 485 h.-p. per 1,000 of population, which places her among the leading nations of the world in per capita utilization of water-power, assumes its true proportions.

Water-Power in the Central Electric Station Industry.—Canada's central electric station industry, the generation or distribution of electrical energy for public use, has attained record proportions because of the wide distribution and accessibility of her abundant water-powers.

The close inter-connection of water-power and the central station industry is evidenced by the fact stated in the discussion of table 2 that almost 81 per cent of Canada's total hydraulic installation is installed for public distribution. As the percentage of hydraulic development for central station use is increasing from year to year the electrical output of hydraulic central stations has shown a corresponding increase over the output of those stations using fuel as a source of primary power until during the year 1925, the last for which definite figures of output are available, over 98·3 per cent of the total electrical output of Canada's central stations originated in the energy of falling water. A number of factors contribute to this continued growth, notably the extensive economic radius of modern electrical transmission combined with the fortunate location of water-powers in relation to centres of population and industry without adequate local fuel supplies.

At the present time there are 303 hydro-electric generating stations in Canada with a combined installation of 3,685,428 h.-p., of which over 3,000,000 h.-p. is developed in the highly industrialized but non-coal producing provinces of Ontario and Quebec. It is interesting to note that while the installations in these two provinces are almost equal, 1,508,266 h.-p. in Ontario and 1,546,692 h.-p. in Quebec, that in Ontario the installation of the commercial stations is less than 40 per cent as large as that of the municipal stations, being only 28·4 per cent of the total for the province while in Quebec the commercial stations have an installation representing 98·8 per cent of the total for that province.

There are in all 213 stations, containing 544 hydraulic turbines of a combined capacity of 2,432,729 h.-p. owned by commercial organizations and 90 stations containing 218 turbines, totalling 1,252,699 h.-p. operated by municipal or other public organizations. The average capacity of the commercial stations is 11,421 h.-p. and of their turbines 4,472 h.-p. as compared with corresponding figures of 13,919 h.-p. and 5,746 h.-p. in the publicly owned stations.

Water-Power in the Pulp and Paper Industry.—Canada's pulp and paper industry, her leading manufacturing industry in point of gross and net values of manufactured products and leading the world in the output of newsprint, owes its outstanding position to the fortunate occurrence of tremendous supplies of pulp wood in close proximity to water-powers capable of being readily developed and of such size as to meet the great power demands of this industry. As the conversion of pulp wood to newsprint requires, on the average, an installation of 100 h.-p. per ton of daily output, the close proximity of power and wood is essential to the successful development of the industry.

The joint development of the central station and pulp and paper industries lends itself to the advantage of both. Power sites can be developed to their full capacity with a certainty of a market for their entire output, any surplus or off peak power being readily absorbed in steam-raising in electric-steam boilers for mill use and owing to the low cost of the installation just as readily released to a more remunerative market when the demand warrants.

There are at the present time some 117 pulp and paper mills in Canada operating water-power developments to furnish their own motive power. These mills have a combined installation of 526,731 h.-p. and a number of them are also large purchasers of power from central electric station organizations. There are still other mills which purchase all their power. While definite figures of this purchased power are not at present available a conservative estimate, recently made, places the amount at approximately 425,000 h.-p., indicating a total utilization of hydraulic power by the pulp and paper industry of over 950,000 h.-p.

PAST AND FUTURE GROWTH IN UTILIZATION OF WATER-POWER

The modern development of water-power in Canada began with the last decade of the nineteenth century by the end of which approximately 170,000 h.-p. had been installed. The development of the long distance transmission of electricity about the beginning of the present century provided a stimulus to hydraulic installation which led to fairly uniform annual increases up to the period of the war. Even during the war and the period of depression which followed a large amount of construction was carried on, though, of course, not at the accelerating rate which might have been anticipated had these conditions not intervened. From 1921 onwards there has been a resumption of activity on a large scale which culminated in the installation of almost 720,000 h.-p. in 1925 following a program of construction extending over several years. Another period of great activity is under way which will result in an installation of 1,700,000 h.-p. in the next few years.

With new uses for electricity constantly developing there is every reason for believing that hydraulic development will show constantly accelerating growth over past figures. Chief among these new uses may be mentioned railway electrification, the application of electric-heat to manufacturing processes, the more extensive use of electric boilers for process steam, commercial and domestic electric refrigeration and other uses constantly appearing. The highest authorities in the electrical field are agreed that the power market has not yet shown any signs of saturation.

CAPITAL INVESTED IN WATER-POWER

The investment represented by our present hydraulic installation of 4,556,-266 h.-p. has been made the subject of intensive study based largely on the figures of the annual census of hydro-electric central stations. Due allowance being made for all the varying factors entering into the development and use of hydraulic power warrants the statement that a conservative estimate of the capital investment in the Canadian water-power industry, including development, transmission and distribution, amounts to over $840,000,000.

COAL EQUIVALENT OF DEVELOPED WATER-POWER

The development of water-power has had a most pronounced effect upon the consumption of coal throughout the Dominion, this being particularly true of the provinces of Ontario and Quebec where no deposits of native coal are found. It is difficult to assign a precise figure for the coal equivalent of developed water-power as the matter is comparative only and assumptions must necessarily be made dependent upon the conditions under which the power is developed. However, taking into account all present conditions surrounding water-power development in Canada and comparing them with somewhat similar conditions of fuel development elsewhere, it is reasonable to state that a saving of coal of six tons per annum is capable of being effected by each installed horse-power. This means that the total present water-power installation of 4,556,000 h.-p. is capable of effecting a saving of about 27,000,000 tons of coal per annum. With the marked economies that are continually taking place in coal consumption in fuel power stations it will be necessary to adjust from time to time the coal equivalent of developed water-power, but under existing conditions the figure of 27,000,000 tons is not unreasonable.

Table 1.—Available and Developed Water-Power in Canada, January 1, 1927

Province	Available 24-hour power at 80 per cent efficiency		Turbine installation h.-p.
	At Ordinary min. flow h.-p.	At Ordinary 6-months flow h.-p.	
1	2	3	4
British Columbia	1,931,142	5,103,460	460,562
Alberta	475,281	1,137,505	34,107
Saskatchewan	513,481	1,087,756	35
Manitoba	3,270,491	5,769,444	227,125
Ontario	4,950,300	6,808,190	1,790,588
Quebec	6,915,244	11,640,052	1,915,443
New Brunswick	50,406	120,807	47,231
Nova Scotia	20,751	128,264	65,702
Prince Edward Island	3,000	5,270	2,274
Yukon and Northwest Territories	125,220	275,250	13,199
Canada	18,255,316	32,075,998	4,556,266

The figures listed in columns 2 and 3 in the above table represent 24-hour power and are based upon rapids, falls and power sites of which the actual existent drop or the head possible of concentration, is definitely known or at least well established. Many rapids and falls of greater or lesser power capacity are scattered on rivers and streams from coast to coast which are not as yet recorded, and which will only become available for tabulation as more detailed survey work is undertaken and completed. This is particularly true in the more unexplored northern districts. Nor is any consideration given to the power concentrations which are feasible on rivers and streams of gradual gradient, where economic heads may be created by the construction of power dams, excepting only at such points as definite studies have been carried out and the results made matters of record.

The figures in column 4 represent the actual water wheels installed throughout the Dominion. These figures should not be placed in direct comparison with the available power figures in columns 2 and 3 for the purpose of deducting therefrom the percentage of the available water-power resources developed to date. The actual water wheel installation throughout the Dominion averages 30 per cent greater than corresponding maximum available power figures calculated as in column 3. The figures quoted above therefore, indicate that the *at present recorded water-power resources* of the Dominion will permit of a turbine installation of 41,700,000 horse-power. In other words, the present turbine installation represents *slightly less than 11 per cent* of the present recorded water-power resources.

The above figures may be said to represent the *minimum water-power possibilities* of the Dominion. As illustrative of this the detailed analyses which have been made of the water-power resources of the provinces of New Brunswick and Nova Scotia have disclosed most advantageous reservoir facilities for regulating stream flow and it is estimated that the two provinces possess within their respective borders 200,000 and 300,000 commercial horse-power. These figures provide for a diversity factor between installed power and consumers' demands.

Table 2.—Developed Water-Power in Canada, January 1, 1927

Province	Turbine Installation in H.-P.				Population June 1, 1926	Total installation per 1,000 population h.-p.
	In central electric stations	In pulp and paper mills	In other industries	Total		
1	2	3	4	5	6	7
	h.-p.	h.-p.	h.-p.	h.-p.		
British Columbia	318,179	80,500	61,883	460,562	568,400	810
Alberta	33,520	....	587	34,107	607,000	56
Saskatchewan	....	....	35	35	823,000	0·04
Manitoba	210,725	....	16,400	227,125	638,000	356
Ontario	1,508,266	174,548	107,774	1,790,588	3,145,600	569
Quebec	1,546,692	242,044	126,707	1,915,443	2,561,800	748
New Brunswick	25,325	13,003	8,403	47,231	407,200	116
Nova Scotia	31,942	16,636	17,124	65,702	540,000	122
Prince Edward Island	279	....	1,995	2,274	87,000	26
Yukon and Northwest Territory	10,000	....	3,199	13,199	12,300	1,073
Canada	3,685,428	526,731	344,107	4,556,266	9,390,300	485

Column 2 includes only hydro-electric stations which develop power for sale.

Column 3 includes only water-power *actually developed* by pulp and paper companies. In addition to this total pulp and paper companies purchase from the hydro-power central stations totalled in column 2, horse-power estimated at about 425,000 h.-p., including a total of about 951,000 h.-p. actually used in the manufacture of pulp and paper.

Column 4 includes only water-power *actually developed* in connection with industries other than the central station and pulp and paper industries. These industries also purchase blocks of power from the central stations totalled in column 2.

Column 5 totals all turbines and water wheels installed in Canada.

Column 6 population at June 1, 1926, as estimated by the Dominion Bureau of Statistics.

Column 7 averages the developed water-power per 1,000 population.

Table 3.—Developed Water-Power in Canada Utilized in the Central Electric Station Industry, January 1, 1927

Province	Commercial Stations					Municipal Stations				
	Number of stations	Number of turbines	Total turbine installation h.-p.	Average h.-p. per station	Average h.-p. per turbine	Number of stations	Number of turbines	Total turbine installation h.-p.	Average h.-p. per station	Average h.-p. per turbine
1	2	3	4	5	6	7	8	9	10	11
British Columbia	20	47	308,084	15,404	6,555	8	11	10,095	1,262	918
Alberta	4	14	32,560	8,140	2,326	1	2	960	960	480
Saskatchewan	....	....	....	....	....	....	....	....	....	....
Manitoba	3	10	106,400	35,467	10,640	2	17	104,325	52,162	6,137
Ontario	76	208	428,675	5,640	2,061	46	133	1,079,591	23,469	8,117
Quebec	88	230	1,527,717	17,360	6,642	16	26	18,975	1,186	730
New Brunswick	5	13	13,915	2,783	1,070	3	6	11,910	3,970	1,985
Nova Scotia	9	12	5,099	566	425	14	23	26,843	1,917	1,167
Prince Edward Island	7	8	279	40	35	....	....	....	....	....
Yukon and Northwest Territory	1	2	10,000	10,000	5,000	....	....	....	....	....
Canada	213	544	2,432,729	11,421	4,472	90	218	1,252,699	13,919	5,746

Commercial Stations include all privately owned.

Municipal Stations include all publicly owned.

NOTE.—The statistics in this table are based upon a census of the industry made by the Dominion Bureau of Statistics in co-operation with the Dominion Water Power and Reclamation Service.

CENSUS OF THE CENTRAL ELECTRIC STATION INDUSTRY

The generation of electricity for public distribution through the medium of the central electric station industry constitutes the leading use to which Canada's hydraulic development is put. In the year 1900, when electricity was just beginning to come into common use, some 32 per cent of the Dominion hydraulic installation was in central electric stations. Ten years later the percentage had almost doubled (61 per cent), while by 1920 over 71 per cent was devoted to this purpose, growing to 81 per cent by the end of the year 1926, while, for the calendar year 1925, 98·3 per cent of the electricity generated for sale in Canada was from water-power.

These facts indicate the close relationship between water-power development and the central electric station industry and the necessity of the annual revision of all basic data relating to the central station industry in order that up-to-date records of water-power resources may be maintained.

This revision is made through the agency of the census of the central electric station industry conducted annually by this service in co-operation with the Dominion Bureau of Statistics of the Department of Trade and Commerce; the Hydro-Electric Power Commission of Ontario, the Quebec Streams Commission, the New Brunswick Electric Power Commission, the Nova Scotia Power Commission, the Manitoba Power Commission and other federal and provincial authorities also provide valuable assistance.

The statistics resulting from this annual census are presented to the public through the medium of the annual reports of the Bureau of Statistics, while at longer intervals, depending upon the varying conditions in the industry, a complete directory showing the investment in plant and equipment, installation, mechanical equipment, service, power for sale, rates and transportation facilities of the individual central electric stations dealt with collectively in the statistical reports of the Census Bureau is compiled and issued by this service. The first edition of this directory was issued in 1919 in order to meet the frequent inquiries for detailed information relative to power supply and the demand for copies was so great that the issue was soon exhausted. Rapidly changing conditions in the industry and repeated requests for the publication of a new edition led to a revised edition being issued as of November 1, 1922. Even greater changes taking place in the industry in the period since the publication of the second directory and a growing demand for up-to-date information necessitated a further revision of our directory records. This was begun in connection with the census taken during the year 1926 and is expected to be completed by the spring of 1928.

DOMINION HYDROMETRIC SURVEY

The Dominion Hydrometric Survey embraces all the provinces of Canada. In the Prairie Provinces the survey is the direct responsibility of the federal Government and in the other provinces it is carried on under co-operative agreements. Standard methods are used both in field activities and in office administration and water resources information covering the whole Dominion is available to the public at one central source. The country is divided into logical divisions of major drainage and these divisions, together with the location of the district office or offices in charge, are as follows: Pacific drainage, Vancouver; Arctic and Western Hudson Bay drainage, Calgary and Winnipeg; St. Lawrence and Southern Hudson Bay drainage, Ottawa and Montreal; Atlantic drainage, Halifax.

The utilization of water resources, particularly in connection with power development and irrigation projects, is continually increasing and there is a pressing demand for detailed and extensive records of the regimen of the numerous lakes and rivers of the country. The importance of stream-flow records is emphasized by the voluntary co-operation afforded the survey by numerous individuals and private corporations.

Run-off Conditions in Canada.—As set forth in detail in the annual reports of the district chief engineers, the average run-off for the year has been subnormal in British Columbia, Alberta, Saskatchewan and Manitoba and above normal in Ontario, Quebec and the Maritime Provinces.

In the Pacific drainage the subnormal run-off which was experienced during the year was particularly noticeable in the Upper Kootenay basin where the yearly run-off amounted to only 67 per cent of the long-term mean.

Typical stations in the Arctic and Western Hudson Bay drainage showed a range in run-off for the year from 25 per cent of the long-term mean on Moose Jaw creek in Saskatchewan to 132 per cent on the English river in western Ontario. Heavy precipitation in southeastern Manitoba and western Ontario during the late summer and autumn months resulted in the filling of all lakes and continuance of run-off until freeze-up.

The run-off from typical stations in the St. Lawrence and Southern Hudson Bay drainage was generally above the average but no excessive flooding occurred during the year.

In the Atlantic drainage the run-off for the year was generally above normal, ranging from 110 per cent to 123 per cent of the long-term mean.

FIELD REPORTS

DISTRICT OF BRITISH COLUMBIA

C. E. Webb, District Chief Engineer

The regular hydrometric investigatory operations of the Dominion Water Power and Reclamation Service have been continued in the British Columbia district, throughout the fiscal year ending March 31, 1927, in accordance with the terms of the co-operative agreement existing between the Department of the Interior and the Government of the province of British Columbia.

ORGANIZATION

Field operations and works are directed from the district head office at 739 Hastings Street W., Vancouver, with a branch office at Kamloops to facilitate investigations in the interior of the province. The primary object of this organization is the acquisition and tabulation of stream-flow data for use in the study of power developments, irrigation, reclamation and domestic water supply but, in addition to this, the services of the staff are largely utilized for the supervision or prosecution of engineering activities on behalf of other government departments which are without hydraulic engineers in British Columbia.

For the Department of Indian Affairs, a large amount of work is performed in connection with the adjustment of Indian water rights in British Columbia, as well as the installation of irrigation systems, drainage, domestic water supply, sewage disposal, river bank protection and electric lighting plants on Indian reserves. During the past year two engineering parties have been maintained in the field while other related matters have been dealt with in the district head office.

CO-OPERATION

All hydrometric studies in British Columbia are made by this service in accordance with the terms of the co-operative agreement with the provincial Government. To fully implement this agreement, stream-flow data are continuously supplied to the Comptroller of Water Rights at Victoria and to interested district water rights engineers throughout the province. A complete run-off record of all streams is also supplied annually to the Provincial Water Rights Branch.

Gauging stations have been maintained in co-operation with the Water Resources Branch of the United States Geological Survey on the Columbia, Pend d'Oreille (Clark Fork) and Okanagan rivers, all of which are most important international streams.

Extensive hydrometric investigations have been conducted continuously in Bridge River district, in co-operation with the British Columbia Electric Railway Company and, during the year, a comprehensive survey of headwaters and tributaries of the Bridge river was completed by this service and a report thereon prepared. Seven regular gauging stations have been maintained and miscellaneous records obtained on eleven other streams.

The hydrometric experience of this service has been advantageously utilized by the city of Vancouver, in the continuance of special investigations to determine and to collect the requisite data concerning the most economical power sites within reasonable transmission distance of the city.

Close relations have been continued with the Greater Vancouver water district with which this service has co-operated extensively, in its investigations for a satisfactory domestic water supply for greater Vancouver.

At the request of the Vancouver and Districts Joint Sewerage and Drainage Board, hydrometric studies were made of Brunette river at the outlet of Burnaby lake and also of the new drainage canal, through which Still creek now enters the lake.

As in previous years, close co-operation has been maintained with the Department of Indian Affairs, on all matters requiring engineering assistance or advice. The investigation of Indian water rights granted prior to March, 1909, has been concluded.

Licences held by the Department of Indian Affairs for the diversion or storage of water for use upon Indian reserves are as follows:—

Agency	Issued under board orders	Issued under applications to comptroller	Totals
Lytton	98	40	138
Kamloops	64	15	79
Okanagan	26	11	37
Williams Lake	19	10	29
Kootenay	11	2	13
Stuart Lake	1	....	1
Vancouver	....	3	3
Babine	1	....	1
Nass	....	1	1
	220	82	302

All works required under conditional licences granted by the provincial Board of Investigation will have to be completed within the time specified under each licence. Satisfactory progress has been made with this work during the year, but close engineering supervision will be required for some years to come, in order that the Department of Indian Affairs may reap the full benefit of water allotted to them.

Close co-operation was maintained with the Dominion Lands administration during the year. When required, investigations are made by this service and reports with plans submitted covering applications to purchase lands in the British Columbia Railway Belt and other problems which confront the administration from time to time. Several such requests have been received during the year, and reports have been submitted or are in the course of preparation.

At the request of the Department of Marine and Fisheries, the professional assistance of this service was extended to that department in the prosecution of intensive hydraulic investigations in connection with alleged obstructions at Hell Gate on the Fraser river, which are said to have seriously impeded the migration of salmon in recent years.

On behalf of the Department of External Affairs exhaustive examination of the alleged pollution of Similkameen and Moyie rivers by smelter waste and tailing was made on the ground, and a detailed report with analyses of water samples was prepared and submitted to that department.

HYDROMETRIC SURVEY

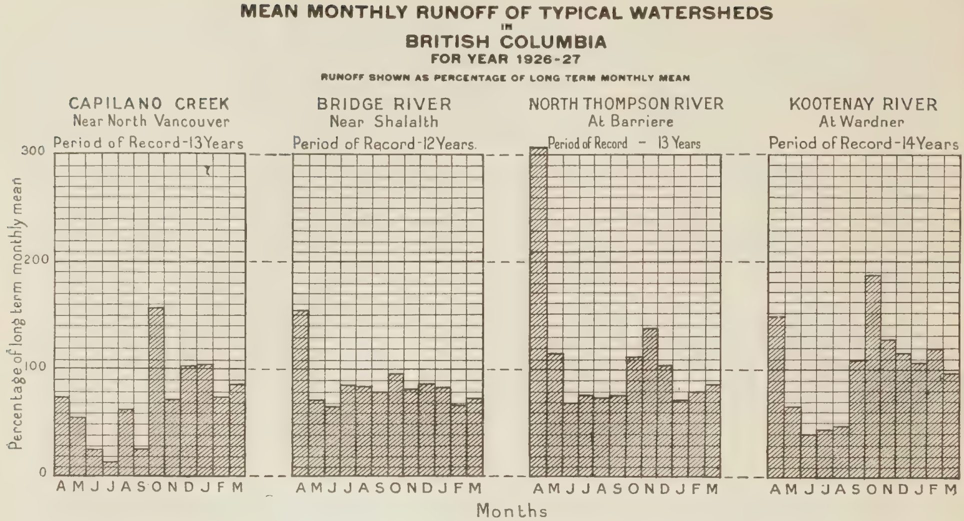
Two hundred and five regular gauging stations were maintained during the year ending 31st March, 1927, on rivers and tributaries in the following main watersheds: Columbia, Fraser, Kettle, Kootenay, North Thompson, Okanagan, Pacific Coast (Mainland), Similkameen, South Thompson, Thompson, Lillooet and Vancouver Island. Many of these stations were maintained for more than one purpose, 78 were maintained for power, 149 for irrigation, 21 for drainage and reclamation, 13 for domestic water supply, 20 for flood purposes, 18 for navigation, 21 for international problems and 8 for statistical purposes. There were 24 new stations established and 5 discontinued. Of the new stations 14 were established at the request of the Provincial Water Rights Branch, in connection with water-power investigations and irrigation problems throughout the province; one was re-established at the request of the city of Grand Forks for power investigation; one at the request of the Vancouver and Districts Joint Sewerage and Drainage Board in connection with sewage disposal; one for the city of Kamloops in connection with storage for power; two for the Greater Vancouver water district in connection with domestic water supply; three for the Dominion Lands administration for domestic supply and irrigation and two for Canadian Forest Products Company in connection with water-power investigations.

During the past year the temperature throughout the province has been slightly above normal, while the precipitation has been below normal.

The subnormal run-off which was experienced throughout the province during the year was particularly noticeable in the Upper Kootenay basin where the yearly run-off amounted to only 67 per cent of the long-term mean. The following are four typical stations in the Pacific Drainage: Capilano Creek near Vancouver, Bridge River near Lillooet, North Thompson River at Barrière, and the Kootenay River at Wardner (see plate 1).

In the Coast area, as typified by Capilano creek, which has a drainage area of 64 square miles, low precipitation and run-off were recorded, the former being 96 per cent of the long-term mean, and the latter 86 per cent. Flood run-off reached a maximum daily discharge of 107 second-feet per square mile in October, as compared with 264 second-feet in October, 1921. The low run-off, which occurred in August was at the rate of 0·47 second-foot per square mile, the same as that recorded in October, 1925, the minimum discharge previously recorded during the past twelve years.

PLATE 1



In the Central Fraser basin, as typified by Bridge river, which has a drainage area of 1,900 square miles, both precipitation and run-off were below normal, the former being 88 per cent of the long-term mean and the latter 82 per cent. The flood run-off reached a maximum daily mean discharge of 6·90 second-feet per square mile in July, compared with 13·7 second-feet in June, 1913. The low run-off, which occurred in February was at the rate of 0·21 second-foot per square mile, as compared with the previous low in the twelve years of record of 0·09 second-foot in November, 1925.

In the North Thompson River basin, as typified by the North Thompson river at Barrière, which has a drainage area of 7,000 square miles, the yearly precipitation was slightly above normal, being 105 per cent of the long-term mean. The yearly run-off was slightly below normal, being 93 per cent of the long-term mean. The flood run-off reached a maximum daily mean discharge of 6·66 second-feet per square mile in May, compared with 11·16 second-feet in June, 1921. The low run-off, which occurred in February, was at the rate of 0·28 second-foot per square mile, as compared with 0·214 second-foot in March, 1919, the minimum discharge recorded during the past twelve years.

In the Upper Kootenay basin, as typified by the Kootenay river at Wardner, which has a drainage area of 5,200 square miles, the yearly precipitation was below normal, being 96 per cent of the long-term mean. The yearly run-off was below normal, being 67 per cent of the long-term mean. The flood run-off reached a maximum daily mean discharge of 3·44 second-feet per square mile in May, as compared with 13·0 second-feet in June, 1916. The low run-off, which occurred in January, was at the rate of 0·29 second-foot per square mile, as compared with 0·12 second-foot in January, 1914, the minimum discharge previously recorded during the past thirteen years.

During the year a Venturi flume was constructed in the diversion of Monte creek to Monte lake for experimental purposes, it being intended to compare results thus obtained with those obtained by the Cippolletti weir system. This season, however, has been such as to preclude a reliable comparison being made and the experiment is, therefore, being continued.

SPECIAL INVESTIGATIONS

Hydrometric investigations, in close co-operation with the city of Vancouver, the Greater Vancouver water district and others in co-operation with the British Columbia Electric Railway Company, have already been referred to. The Greater Vancouver water district, formed last year, is continuing in co-operation with this service. Intensive study of the storage possibilities in Capilano and Seymour creeks in anticipation of the future development of the water system to supply the cities of North Vancouver and Vancouver, as well as the several surrounding municipalities.

During December, heavy flooding occurred on Vancouver island and required a careful examination of the inundated areas and of the probable cause and resultant effect.

The intensive study of the water supply and hydraulic factors of Kootenay lake and river, in connection with power and reclamation projects on the Kootenay river and their possible effect upon international waters, was continued throughout the fiscal year.

DOMINION LANDS ADMINISTRATION

One investigation was made on behalf of the Dominion Lands Branch of the Department of the Interior, and two further requests for investigations were received which will be carried out when weather conditions are suitable.

DEPARTMENT OF INDIAN AFFAIRS

During the year, some forty-three investigations and surveys were carried out on behalf of the Department of Indian Affairs. A wide range of engineering was covered in these investigations and included water storage, irrigation by both gravity and pumping, reclamation, domestic water supply, sewage disposal, river bank protection work and electric lighting for industrial schools and Indian reserves.

Where required, plans, estimates of cost and specifications have accompanied reports on proposed works, for the consideration of the Department of Indian Affairs. Several agreements covering the construction, maintenance and operation of works used jointly with other interests have been put in operation. Considerable construction work resulting from investigations has been carried out throughout the year, both with respect to new projects and repairs to existing works.

Indicative of the nature and variety of the above projects, the following may be cited as typical of this year's undertakings.

Water Storage.—The provision of 500 acre-feet storage in Webb lake was secured by the erection of an eight-foot earth-fill dam requiring approximately 900 cubic yards of material. The water thus stored will be used to irrigate some 250 acres on Canim Indian Reserve No. 1. The expense of installation of an irrigation system was obviated by the utilization of the stream bed from which the water will be distributed by short laterals already constructed to the desired location on the reserve.

Irrigation—Gravity.—An investigation has been made into the possibilities of improving the existing irrigation system from Dog creek for Dog Creek Indian reserves Nos. 1 and 2, by the creation of storage reservoirs in the upper reaches of the drainage area and the distribution of water to irrigable lands on the reserve. Necessary surveys, plans, estimates of cost, etc., were sub-

mitted which include the irrigation requirements for 198 acres on the two reserves. It is anticipated that this work will be undertaken during the coming season.

Irrigation—Pumping.—Following a report, with estimate of cost, this service has now in hand the installation of a new irrigation pumping unit, whereby water will be pumped at the rate of 2,000 gallons per minute from the Thompson river, to be used in the irrigation of a section of very fertile land at the Kamloops Industrial School. The operation of this unit will be watched with interest by people in the vicinity of Kamloops as there is much land in the district which may be brought under cultivation by similar means should this operation prove economical. Hydro-electric power for this unit is obtained from the city of Kamloops.

Domestic Water Supply.—To furnish the Indian village of Bella Coola with an ample domestic water supply and to provide adequate protection in the event of fire, a water supply system was installed capable of delivering 250 gallons per minute from Clayton creek. The works consisted of intake, settling tank and a pipe line about 8,000 feet in length. Provision was made for a future hydro-electric plant by laying a ten-inch pipe line from the intake to the point where power may be developed at Bella Coola river, reduced to five inches beyond that point. Service was provided for 46 houses and 6 hydrants were installed for fire purposes. A suitable shed was built to protect two hose reels, hose and other fire fighting equipment.

Sewage Disposal.—A report, together with plans and estimate of cost, has been submitted, covering the installation of a sewage disposal plant for the new Lytton Industrial School near Lytton, B.C. The proposed system has been designed for a flow of sewage amounting to 5,000 imperial gallons per day or 33 gallons per capita per diem. Sewage from the new school will be carried by means of a 6-inch diameter vitrified sewer pipe to a septic tank to be situated on the left bank of the Fraser river a short distance away. The septic tank will be constructed of reinforced concrete with the top 2 feet below the surface of the ground to avoid danger of freezing. This septic tank, as is usual, will be divided into a settling chamber and a siphon chamber, from the latter the effluent will discharge intermittently into the Fraser river. Sewage will be carried from the school by means of a 6-inch pipe. The size of the pipe from the septic tank to the Fraser river will be 4 inches and it will discharge approximately 1,250 imperial gallons every four hours.

River Bank Protection.—Approval has been given to a recent report covering the installation of river bank protection work on Deadman creek for the protection of Deadman Indian reserve in the Kamloops agency. This project covers the construction of a rock-filled crib wing-dam at the point of erosion, as well as the installation of a pole and brush revetment to protect the river bank.

With the installation of this protection work it is felt that no further erosion may be expected along Deadman creek in the vicinity of the Indian reserve which has been suffering in this regard for a number of years and was liable to be entirely undermined and swept into Deadman creek.

Electric Lighting.—An electric lighting system was installed to provide for the requirements of Squirrel Cove Indian village, Tork Indian Reserve No. 7. The plant consists of a 5 k.w. engine-generator set suitably housed, the necessary poles and complete wiring for seventeen houses and the church. This system is now in full operation and is giving every satisfaction.

The demand for hydrometric data on power streams throughout the province is becoming larger each year. With the increasing settlement of the dry belt of the interior the water situation for irrigation purposes is becoming more and more acute, as time goes on. Hydrometric records on irrigation streams are being utilized to a greater extent in the adjustment of water rights and in the distribution of water for irrigation. Hydrometric data have been in request by many of the larger cities of the province as well as the Board of Fire Underwriters concerning the question of water supply and fire protection. With the increasing shipping facilities and the proximity of hydro-electric power, the centres of population on the Pacific coast are becoming increasingly popular industrially, so that a large demand for hydro-electric power for industrial purposes may reasonably be expected in the not distant future.

DISTRICT OF ALBERTA AND SASKATCHEWAN

A. L. Ford, District Chief Engineer

WATER-POWER AND HYDROMETRIC SURVEY

The stream measurement and power investigatory work of the Dominion Water-Power and Reclamation Service in Alberta and Saskatchewan was continued in conjunction with the Irrigation and Drainage activities, referred to in Part III of this report, during the fiscal year ended March 31, 1927.

From this district office the whole of the province of Alberta, most of the province of Saskatchewan and a small portion of northeastern British Columbia is covered. Owing to lines of communication being through Alberta, the Peace River Block in British Columbia is handled from this office and for the same reason the northeastern or Churchill river area in Saskatchewan is under the supervision of the Manitoba office of this Service.

ORGANIZATION

Since the amalgamation of the Dominion Water Power Branch with the Reclamation Service in 1923 all functions in regard to the investigation, utilization and administration of water resources in the provinces of Alberta and Saskatchewan have been combined and carried out by a single field organization with headquarters in the Southam Building at Calgary, Alta. As a matter of economy in covering this large territory, subdistricts have been created and each placed under the charge of an engineer who carries on the hydrometric field investigations as well as those of an irrigation, drainage or water-power nature. These officers report to and are controlled from Calgary where all data are collected, compiled and filed.

CO-OPERATION

During the year the same co-operative arrangements with the Montana Division of the United States Geological Survey and the United States Bureau of Reclamation in regard to the collection of stream-flow records on international waters along the boundary between the provinces of Alberta and Saskatchewan and the State of Montana were continued. These duties devolve on this service through the requirements of the International Joint Commission under the provisions of the International Waterways Treaty. In this connection it is desired to record the very helpful assistance which is given each year to our staff by members of the United States services in connection with this work.

Looking to the solution of problems in connection with the irrigation systems of the Canadian Pacific Railway Company and the Canada Land and Irrigation Company in Alberta our staff has co-operated with their officials and engineers to the mutual advantage of both organizations.

Active co-operation was carried out with the Lethbridge Northern irrigation district, and with officials of other irrigation and power projects in regard to stream and canal-flow problems was continued with excellent results.

The co-operative arrangements carried out with other departments, the provincial Governments, railway corporations and several municipalities have been continued and extended during the year. Many phases of the water supply problems of these organizations have been studied and with their assistance valuable hydrometric data have been obtained which are not only of interest to them but also of general value.

Again during the past fiscal year the lectures and demonstrations on hydrometric and water-power methods were carried out at the University of Alberta and the University of Saskatchewan. At the University of Saskatchewan active assistance was given in the way of advice and loan of equipment in connection with a study the university is making of run-off from prairie areas.

HYDROMETRIC SURVEY

During the fiscal year ended March 31, 1927, 257 gauging stations were maintained on rivers, lakes, canals and ditches in the following main watersheds: Assiniboine, Athabaska, Bow, North Saskatchewan, Peace, Saskatchewan, and South Saskatchewan rivers. Of these 47 were all-year stations and 210 were operated during the open-water season only, 14 were maintained for power, 153 for irrigation, 22 for drainage, 13 for domestic water supply, 6 for flood warning, 36 for international purposes and 13 for statistical information, in addition to these miscellaneous measurements were obtained at 60 other points. The small reduction in the number of stations operated during the past year is due to the discontinuation of the Lake Newell investigation and the dropping of several small open water stations where sufficient observations have been secured to serve the purpose required.

Following a winter of unprecedented mildness and light precipitation most of the streams in Saskatchewan and Alberta broke up in March, 1926. Prairie streams were decidedly sub-normal and mountain-fed streams somewhat above normal for April. During the following four months, however, both classes of stream were much below normal, giving run-off figures in many cases less than 50 per cent of the mean. Frequent rains were recorded during the growing season but were not of sufficient intensity to produce much run-off.

Beginning with September 1, a torrential rain began, centering in the Rockies over the headwaters of the North Saskatchewan and Bow rivers and extending with diminishing intensity north to the Yellow head pass and south to the International Boundary. In eleven days 7·75 inches fell at Calgary and the total for September was 8·78 inches, the highest recorded in the last 42 years, the previous highest being 5·08 inches in 1925 and 3·99 inches in 1900. This precipitation caused maximum September run-off in very many streams in the storm area and indeed maximum discharges for the period of record on 18 streams. Following this, with fair monthly precipitation, run-off has ruled somewhat above normal throughout a steady winter.

PLATE 2

MEAN MONTHLY RUNOFF OF TYPICAL WATERSHEDS IN ALBERTA FOR YEAR 1926-27

RUNOFF SHOWN AS PERCENTAGE OF LONG TERM MONTHLY MEAN

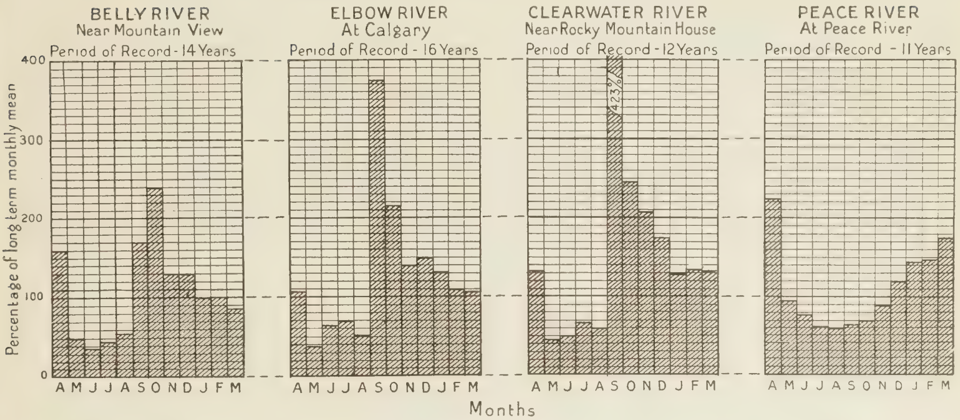
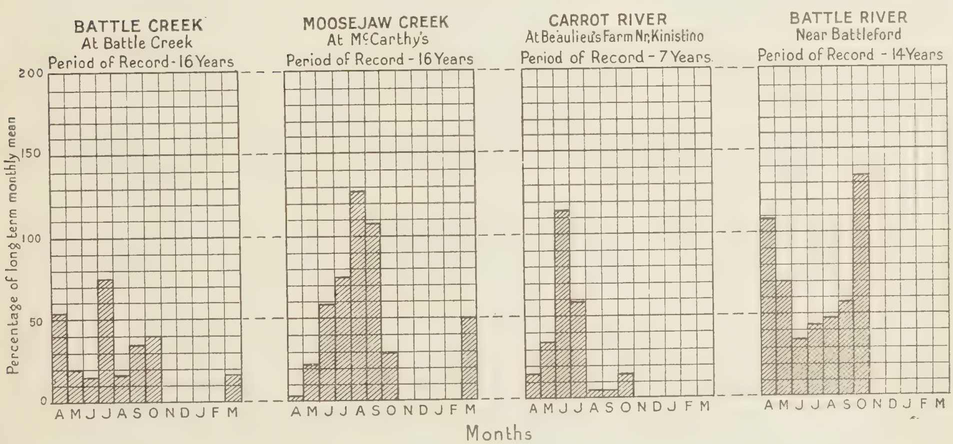


PLATE 3

MEAN MONTHLY RUNOFF OF TYPICAL WATERSHEDS IN SASKATCHEWAN FOR YEAR 1926-27

RUNOFF SHOWN AS PERCENTAGE OF LONG TERM MONTHLY MEAN



Snow cover in northern Alberta and Saskatchewan during the past winter was rather heavy and in Saskatchewan between Manyberries and Shaunavon and south of the Cypress hills, considerably more snow than usual was recorded. Between Medicine Hat and Swift Current and extending from the Cypress hills some distance north beyond the main line of the Canadian Pacific railway the snow cover has been sparse, while in southwestern Alberta "chinook" winds have cleared away the snow at different times.

During the fiscal year the temperature ruled above average and a compilation from the records of ten stations distributed over the two provinces gave a mean yearly temperature for the year one degree above the average.

For the purpose of illustrating the general run-off conditions in Alberta and Saskatchewan graphs showing the variation from the mean, month by month, for four typical stations in each province have been prepared and are attached.

(See Plates 2 and 3.) Those selected for Alberta are the Belly River station near Mountain View, the Elbow River station at Calgary, the Clearwater station at Rocky Mountain House and the Peace station at Peace River and, for Saskatchewan, Battle Creek station at Battle Creek, Moosejaw Creek station near Moose Jaw, the Carrot River station near Kinistino, and the Battle River station near Battleford.

In southern Alberta, as typified by the Belly river, precipitation was below normal and the run-off 73 per cent of the long-term mean. Flood run-off reached a maximum daily discharge of 5·851 second-feet per square mile in April and May as compared with 20·471 second-feet per square mile, the maximum for the period of record. The low run-off which occurred in March was at the rate of 0·314 second-foot per square mile as compared with 0·182 second-foot per square mile, the lowest so far recorded.

For south central Alberta the typical stream selected is the Elbow river. The precipitation on the lower reaches of this stream was 48 per cent above average, but for the mountain area was below average and the run-off for the year was 93 per cent of the long-term mean. Flood run-off reached a maximum daily discharge of 6·674 second-feet per square mile in September as compared with 25·107 second-feet, the maximum for period of record. The low run-off which occurred in February was at the rate of 0·215 second-foot per square mile as compared with 0·039 second-foot, the minimum discharge from previous records.

In north central Alberta, as typified by the Clearwater river, precipitation was above normal and the run-off 121 per cent of the mean for twelve years. The maximum run-off produced a daily discharge of 6·771 second-feet per square mile in September as compared with 32·208 second-feet per square mile. the maximum run-off previously recorded. The minimum daily flow occurred in April at the rate of 0·185 second-foot per square mile, as compared with 0·058 second-foot, the minimum from previous records.

Representative of northern Alberta the precipitation and run-off for the Peace river were below normal, the former being 92 per cent of the long-term mean and the latter 84 per cent. The flood run-off reached a maximum daily mean discharge of 4·014 second-feet per square mile in June as compared with a daily discharge of 5·201 second-feet, the highest run-off on record. The low run-off which occurred in April was at the rate of 4·207 second-foot per square mile as compared with 0·093 second-foot per square mile, the lowest so far recorded.

Typical of southern Saskatchewan, Battle creek shows a subnormal precipitation and a very low run-off of 38 per cent of the average. Flood discharges reached a maximum daily rate of 2·300 second-feet per square mile in April, as compared with 5·771 second-feet per square mile, the highest run-off on record. Low run-off which occurred in July and August was at the rate of 0·007 second-foot per square mile, as compared with a total absence of run-off in previous records.

In southeastern Saskatchewan, typified by Moosejaw creek, the precipitation was slightly below normal and the run-off was decidedly low, being 19 per cent of the long-term average. Flood run-off reached a maximum daily discharge of 0·063 second-foot per square mile in June as compared with 1·509 second-feet per square mile, the maximum for period of record. Minimum flow at various times was nil.

For northeastern Saskatchewan, the typical steam selected is the Carrot river. The precipitation in this area was about normal but the yearly run-off was very low, being 38 per cent of the long-term average. Maximum run-off occurred in May and was at the daily rate of 0·198 second-foot per square mile, as compared with 4·302 second-feet, the maximum as heretofore recorded. The minimum run-off was nil at various times.

In northwestern Saskatchewan, as typified by the Battle river, precipitation was slightly below normal and the run-off 72 per cent of the average. Flood run-off in April reached a maximum daily discharge of 0·340 second-foot per square mile, as compared with 0·970 second-foot per square mile, the maximum on record. The low run-off occurring in March was at the daily rate of 0·001 second-foot per square mile as compared with nil discharge at various other times.

CURRENT METER RATING STATION

The only fully equipped current-meter rating station in Canada is operated by this organization at Calgary. Here all instruments used by this service and many other organizations are rated. At the station, meters are rated as received from the field so that recent measurements can be re-computed if necessary. Following the first rating, the instrument is checked over and, if necessary, repaired. It is then rated again before being returned to its user. During the fiscal year 1926-27 the station was in operation from May 6 to November 4. A total of 103 current-meters were rated, 154 ratings were made, and 67 instruments were repaired in various degrees. Of the instruments calibrated, 1 was for the Department of Public Works, British Columbia; 2 for the Canada Land and Irrigation Company; 3 for the S. E. Junkins Company; 3 for the Canadian Pacific Railway, Department of Natural Resources; and 1 for the Lethbridge Northern Irrigation District. The remainder were received from offices of the service as follows: Ontario, 13; British Columbia, 21; Quebec, 6; Manitoba, 11; Alberta and Saskatchewan, 38; Nova Scotia and New Brunswick, 4. The work of improving the fencing and of relaying the rating station track was completed during the early part of the spring. The apparatus used for calibration purposes has been improved in minor details and the general efficiency of the equipment increased.

A considerable amount of experimental work is carried on to determine the behaviour of various types of meters under both normal and exceptional conditions. All such data are on file and can be supplied on demand.

SPECIAL INVESTIGATIONS

Since 1921 this service has had charge of the operation of the storage reservoir at lake Minnewanka in the Banff National park during the filling season, accordingly the supervision of operations at the dam at the outlet of the lake was assumed on May 10, 1926, and continued until October 1, when the tourist season in Banff park had closed and lake Minnewanka being approximately at upper regulation level, the handling of the reservoir was turned over to the Calgary Power Company. As during the winter of 1925-26 the snowfall was much below normal in the mountains, the run-off during the earlier part of the season was, as anticipated, comparatively light, so that, while care had to be exercised, the water level was brought to the elevation desired by the officials of the Canadian National Parks Branch, Department of the Interior, and held at that point until the end of August when it was brought to upper regulation level. At the initiative of this service, an agreement was reached between officials of the Canadian National Parks Branch and the Calgary Power Company under which the level of the wharf at lake Minnewanka was raised, the work being completed before the commencement of the filling season of 1926. This greatly facilitated the operation of storage and eliminated any tendency to friction between the different interests at lake Minnewanka.

The application of the East Kootenay Power Company to develop power at the Crowsnest Falls power site on the Crowsnest river in southwestern Alberta has been withdrawn. This company, which generates power at sites

on the Elk river and the Bull river in British Columbia and distributes electrical energy in both British Columbia and Alberta, has been forced by the increased demand and lack of storage reservoir facilities to undertake the erection of a 5,000-k.w. steam-power plant near the outlet of Crowsnest lake in Alberta. There has been no activity in connection with the remaining applications.

Several requests have been received for information regarding small water-power sites and the method of securing rights for development on these sites. One inspection was made on new applications received during the year and a report submitted. Three inspections were made on old developments of small power sites in the district west of Red Deer and one inspection on an old application upon which no development work had been done. Reports were submitted recommending cancellation for three of these applications and an extension of time in the remaining case.

During the year an office study was made of the effect that storage for power purposes on the upper tributaries of the Bow river would have on irrigation projects, existing and proposed, on the lower reaches of this river. It was found that with proper regulation there would not necessarily be any conflict between these interests.

As elsewhere in Canada, the use and demand for electric energy for light and power is continually increasing in the cities and towns of Alberta and, where the presence of low voltage lines make it possible. At Calgary the consumption of power during 1926 was 7·7 per cent greater than in 1925. As the new Spillers Mill, with a demand for some 1,500 h.-p., and the Riverside Iron Works with a demand for 500 k.w. will be requiring power, the rate of increase will probably be greater in 1927. Already the peak power load at Calgary has taxed the two hydro-power plants of the Calgary Power Company on the Bow river at Seebe, together with the municipal steam plant, used as an auxiliary, during periods of low flow in the Bow river. The company has, therefore, increased the mechanical efficiency of the hydro-plants by replacing the runners in one turbine and rewinding two generators. With preliminary assistance from officers of this service, the company has devoted a great deal of time and care during the past year to the rating of their units at both Kananaskis and Horseshoe Falls plants in order to operate them at best efficiency, and by means of long-distance gauges has arranged to check the available water supply against the power output to eliminate, as far as possible, any waste in methods of operation. The pondage at the Kananaskis plant was also increased by the company during the year so that any sudden decrease in the Bow River flow due to unforseen ice conditions will not so immediately affect the output and more time will be allowed for necessary adjustments at the steam stand-by plants.

During the latter part of 1926, under agreement with the town of High River, Alta., the Calgary Power Company constructed a transmission line from Calgary to High River to supply light and power to that town. This was later extended to Blackie, and a tap line was also taken from the main line to supply the town of Okotoks. These lines are now in operation. Inspections of these transmission lines were made by officials of this service and special inspections and reports made in cases where difficulties arose over the acquirement of right of way. The difficulties were ultimately settled without expropriation proceedings.

Immediately after the granting of the franchise in High River, the Calgary Power Company was approached by several towns south of High River. Of these, Nanton has now by almost unanimous popular vote declared in favour of granting a franchise to the company and the latter has made surveys of the transmission line. The city of Lethbridge, the chief power user in the area, has been approached by the company and negotiations are now under

way. Other companies are also in competition for this market. Towns between High River and Lethbridge, and more particularly between Blackie and Lethbridge, are now actively negotiating for hydro power with the Calgary Power Company and consideration is being given to this form of power by one or two towns south of Lethbridge. From the above the active interest in power that is now being shown throughout a large portion of the province of Alberta is evident.

The investigation of absorption losses in Lake Newell reservoir of the Eastern Section of the Canadian Pacific Railway Company's irrgation system which was started in 1920 was concluded in 1925 and a report of this investigation is now practically completed.

Two distinct investigations were carried out on the Lethbridge Northern Irrigation District system. These were started in 1925 and continued in 1926. The first was an investigation of carriage losses on the main canal from the headgates to below the Willow Creek flume. Many valuable data have been obtained as to the losses in various classes of material through which this canal passes. The second investigation was of the losses in Keho Lake reservoir, and data of general interest on reservoir design and operation resulted therefrom. Progress reports covering the findings have been prepared and submitted.

In May the investigation of snow conditions in the upper St. Mary basin was carried out jointly with the District Engineer of Montana Division of the United States Geological Survey. This investigation, which has been in progress for five years, is gradually accumulating very useful data on which to forecast seasonal run-off of the St. Mary river which is a most important international irrigation stream. Being a year of low run-off, 1926 gave most valuable information.

In order that the flow of the minor tributaries of the Milk river crossing the international boundary should be recorded, an inspection was made of this territory by engineers representing the United States Geological Survey and this service in June of 1926. Eight new international hydrometric stations were recommended and were being installed at the close of the fiscal year.

In connection with the diversion of the waters of these northern tributaries of the Milk river, an investigation of the seepage losses in the Canadian portion of Battle creek was made in 1925. It is necessary to continue this study with particular reference to return flow from land irrigated from this stream. The preliminary steps for the 1927 season's field work in this connection were taken during the fall of 1926 and the necessary hydrometric stations were located and equipment installed.

In addition to requests for ordinary stream-flow records, the service receives and supplies material for a large number of requests for miscellaneous data, such as temperatures, precipitations, water levels, and other information touching on our work. During the fiscal year records from 204 of the regular gauging stations were supplied, as well as other data of a power or hydrometric nature. Unlike recent years, very few flood warning despatches were necessary as the only really high stages of the year occurred on the North Saskatchewan and Bow rivers in September when the danger stages lasted but a short time.

The hydrometric data obtained by this service was used in connection with the operation of the Eastern and Western Sections of the Canadian Pacific Railway Company's irrigation system, the Alberta Railway and Irrigation Company system, the Lethbridge Northern Irrigation system, the Canada Land and Irrigation Company system, the New West Irrigation system, the Taber Irrigation system, the power plants of the Calgary Power Company, as well as in connection with the design of dams and water-supply systems of the Canadian National and Canadian Pacific Railway companies. Also data were used by various other engineers in connection with the design and investigation of numerous power projects.

DISTRICT OF MANITOBA

C. H. Attwood, District Chief Engineer

During the fiscal year ended March 31, 1927, the regular stream measurement and power investigatory operations of the Dominion Water Power and Reclamation Service in the Manitoba and adjacent districts have been continued.

The scope of the work covered by this district organization comprises the hydrometric, power, storage and reclamation investigatory work in Manitoba and the Churchill River section of northeastern Saskatchewan, and also the hydrometric work in that portion of western Ontario, inclusive of and lying to the west of the Nipigon river.

ORGANIZATION

The local organization of the Dominion Water Power and Reclamation Service, headquartered in the Commercial Building, Winnipeg, was organized in 1912 and the work then instituted has been carried on and extended from time to time. The duties of the engineers and the hydrometric recorders consist of both field and office work, including surveys, investigations, inspection and supervision of construction, and the preparation of the data collected in report form, for submission to the head office.

CO-OPERATION

The organization works in co-operation with several departments of the federal Government and with the Power Commission and Reclamation Service of Manitoba.

HYDROMETRIC SURVEY

During the past year 102 regular and 18 miscellaneous stations have been maintained on lakes, rivers and tributaries in the following main watersheds: Nelson, lake Winnipeg, Winnipeg river, Lake of the Woods, Rainy Lake and English, Red, Assiniboine, Dauphin and Saskatchewan rivers.

Of the above regular stations there were maintained for power and storage 57 all-year, 5 during open water, and 6 miscellaneous; for drainage and reclamation throughout the year, 9 regular, 22 during open water, and 12 miscellaneous. Five regular all-year stations, together with 5 open-water were maintained for flood study. On international streams 13 all-year and 8 open-water regular stations were maintained, together with 6 miscellaneous. For water supply, 4 regular stations were maintained during open-water and for statistical purposes 5 all-year stations, while for meteorological purposes 11 stations were maintained continuously. In the above classification a number of stations have been maintained for more than one purpose.

Throughout Manitoba the run-off for the year has been low as compared with the mean for the period of record. In the midwestern section of the province, as exemplified by the Swan river, the average run-off was 67 per cent of the period of record and in the southwestern section, as exemplified by the Assiniboine river, the run-off was only 49 per cent of the long-term mean. The flood run-off showed a corresponding decrease, that of the Swan river being 3·671 second-feet per square mile, or 53 per cent of the previous maximum, and the Assiniboine 0·070 second-foot per square mile, or 19 per cent of the previous maximum. The minimum run-off occurred during the winter months with 0.006 second-foot per square mile in March on the Assiniboine and 0·007 in February on the Swan. Both of these exceed the previously recorded minimums, which were 0·001 and 0·000. respectively.

Precipitation during the year in the above areas was near normal, that in the Swan watershed being 93 per cent of the mean and 99 per cent in the Assiniboine watershed.

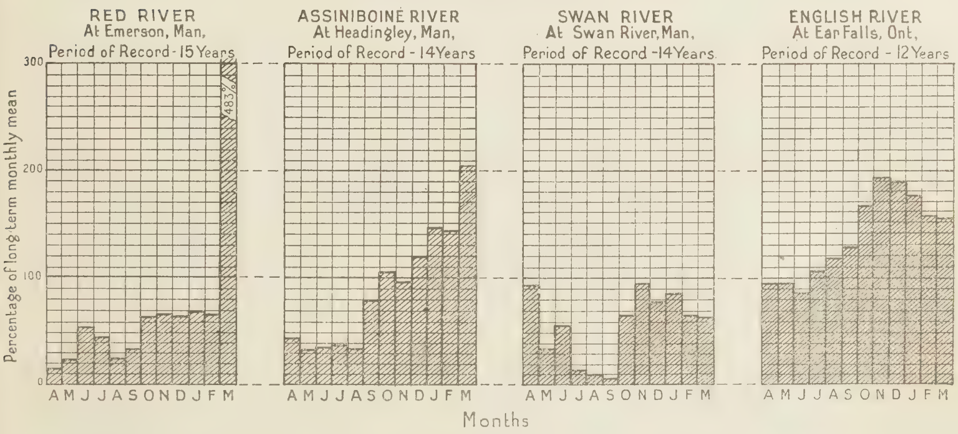
In the southerly portion of the province, as typified by the Red river, the average run-off was low, being only 53 per cent of the mean, with precipitation on the watershed 96 per cent of the long-term mean. The run-off during flood, 0·231 second-foot per square mile, was very low, being only 17 per cent of the previously recorded maximum. The minimum for the year was 0·007 second-foot per square mile in September, compared with 0·003, the minimum for the period of record.

In the Laurentian areas in the southeasterly portion of Manitoba and the extreme westerly section of Ontario, run-off as typified by the English river was considerably above normal, being 132 per cent of the long-term mean, while precipitation was 93 per cent of the mean. The maximum run-off was 0·957 second-foot per square mile, being 53 per cent of the previously recorded maximum, while the minimum was 0·299 second-foot per square mile, compared with 0·263, the lowest recorded.

Due to the heavy precipitation in the fall, extensive flooding occurred in October on the Roseau river, the low march lands lying on both sides of the river from the international boundary to Stuartburn being inundated. Though a fairly high run-off was recorded, little of the flooding came from the river overflowing its banks, but was mainly due to the low-lying areas becoming saturated and being unable to absorb the continued precipitation.

Plate 4

MEAN MONTHLY RUNOFF OF TYPICAL WATERSHEDS IN MANITOBA
FOR YEAR 1926-27
RUNOFF SHOWN AS PERCENTAGE OF LONG TERM MONTHLY MEAN



SPECIAL INVESTIGATIONS

Upper Rainy Boundary Waters.—The field investigatory work necessary for the proper consideration of the Reference in respect to the Rainy and the Upper Boundary lakes, now before the International Joint Commission, was continued on several of these lakes during the past season. The survey party, consisting of 15 men was in the field from the middle of May until early in October, and the work extended from the upper end of Iron lake to the outlet of Loon lake. The surveys were limited to completing and amplifying the work previously done by the International Boundary Survey, and consisted of secur-

ing the information necessary to delimit the contours between shore-line and elevation 1235 on Iron lake, and between shore-line and elevation 1200 on La Croix and Loon lakes and adjacent waters.

In connection with the possible flooding of lands surrounding these lakes and consequent damage to the standing timber, the co-operation of the Forest Service was secured to make an estimate of the value of the timber between the shore-lines and the limiting contours. This work was commenced late in the season and covered only Loon lake and the adjacent area, but will be completed during the ensuing season.

Close co-operation was maintained with Major Crawford, U.S. Engineer in charge of the surveys at the upper end of the watershed.

Catfish Creek Drainage.—Following the surveys made during the early part of last year, a certain amount of progress was made with construction on the Catfish Creek drainage project during the year. The channel constructed in 1924 was enlarged to conform with the approved plans and an additional 3,600 feet of channel excavated. This comprised the continuation of the old channel southerly to the Canadian National Railway and then running east along the road allowance to a quarter of a mile east of the northwest corner of Section 29.

Manitoba Dairy Farms, Limited.—On application by the Manitoba Dairy Farms, Limited, for permission to lease and drain certain lands in Townships 4 and 5, Range 9, of the east Principal meridian, an investigation was made jointly with the provincial officials with reference to the feasibility of the proposed reclamation project. Following this investigation an agreement was entered into with the company whereby, under the supervision of the federal and provincial authorities, surveys are being carried on and drainage ditches are to be constructed as required necessary for the proper reclamation and settlement of the land.

Co-operation with Department of Indian Affairs.—In September this office acted in an advisory capacity with reference to the protection from frost of the Sioux Lookout Indian School water supply system with particular reference to the water supply intake. A personal inspection was made of the conditions and it was recommended that the intake be encased in a timber crib with a filling of earth and stone. This recommendation was approved and the work carried out under the supervision of the Department of Indian Affairs.

In March, 1927, an inspection was made of the water works system of the Indian School at Fort Alexander and a report recommending certain improvements, together with estimates of their cost, was submitted to the Department of Indian Affairs.

Co-operation with Forest Service, Department of the Interior.—In March the Forest Service requested that this office confer with the Chief of the Tree Planting Division of the Forest Service at Indian Head, and advise him on certain extensions to the water supply system necessary for the installation of a Skinner Sprinkling System of irrigation for the 10-acre transplanting plots. After an examination of the system already installed, a report, together with estimates of costs covering the proposed extension, was prepared and submitted to the Forest Service. An improved type of installation was recommended and was carried out during the past summer under the supervision of the Chief of the Tree Planting Division.

Great Falls.—Considerable construction work was carried on by the Manitoba Power Company at Great Falls during the year. Unit No. 3 was completely installed, given an initial test on November 23 and shortly afterwards

was put into operation. The unit is similar to Nos. 1 and 2. This brings the installed capacity of the plant to 84,000 h.-p.

The high tension switching equipment was completely changed, a new bank of 21,000 kv.a. transformers and a new 110,000-volt high tension "bus" was installed and the two existing busses were re-designed to permit of increasing the voltage from 66,000 to 110,000 volts.

The decision of the power company to raise the forebay level to elevation 812 under the conditional approval of the department as a temporary measure, necessitated the completion of the dam and dyke in accordance with the original scheme of development. The uncompleted portion of the non-overflow section at the west end of the power-house was completed, about 900 cubic-yards of concrete being poured. Heavy steel frame-work was also erected on the crest of the spillway section of the dam which, by permitting the placing of stop logs along the complete length, converts it, when desired, into a non-overflow section. In addition, in view of the contemplated raising of the forebay, the clearing was carried to 814 and a dyke about 16,500 feet in length was constructed along the west bank. This was accomplished by raising the Winnipeg River railway embankment to elevation 817, by dumping 86,000 yards of earth and 3,900 yards of ballast, together with the placing of 10,000 yards of broken rock as rip-rap along the face. On the rock-fill dam some 28,000 yards of clay were dumped along the upstream face in an endeavour to minimize the leakage.

In addition to the construction work at the power plant a steel-tower transmission line was built from the Great Falls plant to the Manitoba Pulp and Paper Company's mill at Pine Falls and is delivering power to operate that plant. There is also being constructed and nearing completion a transmission line from the Great Falls plant to the mines of the Central Manitoba Mines Company at Bulldog lake.

To provide for the increasing market for power, contracts have been let for the installation of unit No. 4 and for the immediate completion of the power-house superstructure.

Point du Bois.—The installation of units Nos. 15 and 16 during the year by the city of Winnipeg completed the power installation at Point du Bois, bringing the total installation to 109,000 h.-p. The new units comprise turbines of 7,600 h.-p. and generators of 6,500 kv.a. with direct-connected exciters. In addition one 9,000 k.w. bank of transformers was replaced by one of 15,000 kv.a.

The complete installation of the power-house necessitated the enlargement of the intake canal in order to prevent undue loss of head. Of the three years program covering this work certain improvements were carried on at the entrance to the canal involving the excavation of 1,000 cubic-yards of rock.

Keewatin Power Company-Norman Dam Power House.—With the installation of Units Nos. 4 and 5 in the early part of the year the initial development as planned is now completed. In addition to the above the construction work on the dam was completed by the pouring of the reinforced concrete dam slab over sluices 10 to 20 inclusive.

The installation comprises five vertical turbines of 3,400 h.-p. at 22-foot head, direct-connected to generators of 3,300 kv.a. Provision for the ultimate installation of two additional units is provided for in the substructure and superstructure of the power-house.

Efficiency tests which were carried out in July showed a maximum overall efficiency of 86·5 per cent and a maximum wheel efficiency of 90·2 per cent under a 22-foot head.

DISTRICT OF ONTARIO

N. Marr, District Chief Engineer

During the fiscal year ended March 31, 1927, the regular stream measurement and power investigatory operations of the Dominion Water Power and Reclamation Service in the province of Ontario have been continued in accordance with the terms of the co-operative agreement of October 1, 1919, between the Department of the Interior and the Hydro-Electric Power Commission of Ontario.

ORGANIZATION

The work of the Ontario Hydrometric Survey was carried on under the direction of the District Chief Engineer with a head office at 81 Metcalfe street, Ottawa. The greater part of the field operations was carried out by the field staff from the North Bay office. The hydrometric investigations in that part of the province west of and including the Nipigon river were, as in previous years, carried on under the direction of the district office at Winnipeg while twelve stations on streams tributary to the Ottawa river which, being in the province of Quebec would ordinarily come under the supervision of the District Chief Engineer at Montreal, were for reasons of economy handled by the Ottawa office.

CO-OPERATION

In pursuing the field and office investigations, the closest co-operation has been maintained with the officers of the Hydro-Electric Power Commission of Ontario. Valuable assistance has also been given the engineers of the district by various persons and corporations interested in the securing of hydrological data. In particular, reference should be made to the co-operation carried on with the following companies: The Abitibi Power and Paper Company; the International Nickel Company of Canada; the Kaministiquia Power Company; the Mattagami Pulp and Paper Company; the Mississippi River Improvement Company; the Pigeon River Lumber Company; the Spanish River Pulp and Paper Company; the Spruce Falls Company; the Northern Ontario Power Company, and the Gatineau Power Company.

HYDROMETRIC SURVEY

During the fiscal year ended March 31, 1927, 59 regular stations were maintained on rivers and tributaries in the following main watersheds: Hudson Bay, lake Superior, lake Huron, lake St. Clair, lake Erie, lake Ontario and Ottawa river.

Of these, 50 were maintained throughout the year for power purposes, five were maintained throughout the year and two during spring run-off for flood study; one for the purpose of domestic water supply and one on an international power control problem.

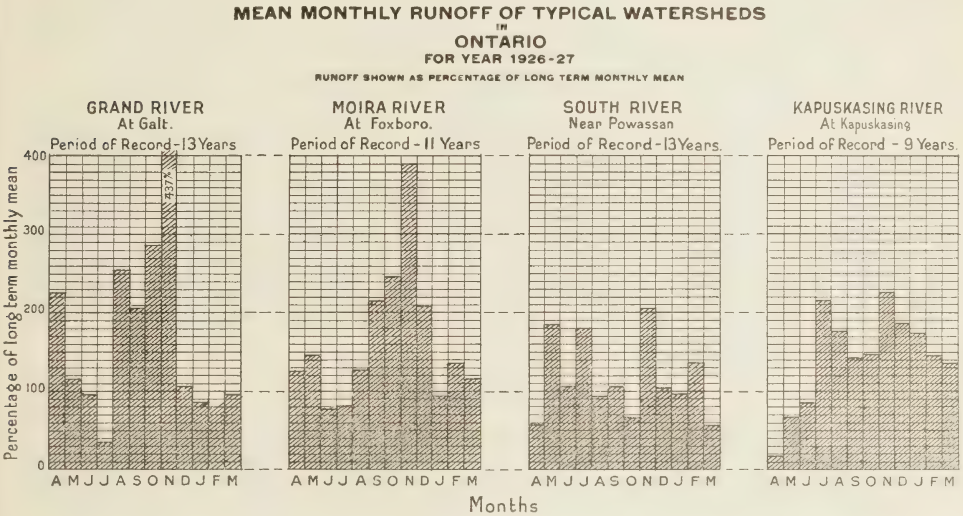
For the purpose of illustrating the general run-off conditions in Ontario, graphs showing the variation from the mean month by month, for four typical stations, have been prepared and are attached (see plate 5). The stations selected are on the Grand river at Galt, the Moira river at Foxboro, the South river at Powassan, and the Kapuskasing river at Kapuskasing.

In the southwest portion of the province, as typified by the Grand river, precipitation was above normal and the run-off 159 per cent of the long-term mean. Flood run-off reached a maximum daily discharge of 11·015 second-feet per square mile in March, as compared with 22·125 second-feet per square

mile, the maximum for the period of record. The low-run-off, which occurred in August, was at the rate of 0·070 second-foot per square mile, as compared with 0·036 second-foot per square mile, the lowest so far recorded.

For the eastern portion of the province the typical stream selected is the Moira river at Foxboro. The precipitation was well above normal and the run-off for the year was 144 per cent of the long-term period. Flood run-off reached a maximum daily discharge of 8·516 second-feet per square mile in March, as compared with 12·003 second-feet per square mile, the maximum for the period of record. The low run-off, which occurred in August, was at the rate of 0·128 second-foot per square mile, as compared with 0·014, the minimum discharge so far recorded.

Plate 5



In the North Bay district, the typical stream selected is the South river at Powassan. The precipitation was above normal and the run-off for the year was 110 per cent of the long-term period. Flood run-off reached a maximum daily discharge of 13·741 second-feet per square mile in July, as compared with 16·735 second-feet per square mile, the maximum for the period of record. The low run-off, which occurred in September, was at the rate of 0·388 second-foot per square mile, as compared with 0·184, the minimum discharge so far recorded.

For the northern portion of the province the typical stream selected is the Kapuskasing river at Kapuskasing. The precipitation was above the average and the run-off for the year was 117 per cent of the long-term mean. Flood run-off reached a maximum daily discharge of 3·605 second-feet per square mile, as compared with 13·049 second-feet per square mile, the maximum for the period of record. The measurements of low flow cannot be taken as an indication of the minimum run-off from this drainage area because they are affected by the operation of a power plant above the gauging station.

SPECIAL INVESTIGATIONS

The analysis of the water-power and storage resources of Ontario was continued during the year in close co-operation with the provincial authorities.

During the year, a station was established on the Mattagami river at

Smoky Falls. Information is being obtained which will be useful to the company at present developing the site.

Special study of the hydrology of the Niagara river was continued throughout the year and very satisfactory results obtained in the investigation of discharge referred to the Buffalo breakwater gauge. The studies of river slopes and the effect of diversions in governing pool levels have also been continued.

The International Lake Superior Control Board, in the exercise of its duties in connection with the regulation of the level of lake Superior, has been recalibrating the discharge through the dam at Sault Ste. Marie and the channels leading from lake Superior. In this work the Dominion Hydrometric Survey, through the Ontario staff, has afforded the assistance of its officers to the board.

DISTRICT OF QUEBEC

L. G. Denis, District Chief Engineer

Basic investigatory work on water-power and allied matters was continued throughout the year in Quebec province by the Dominion Water Power and Reclamation Service in conformity with the co-operative agreement between the department and the Quebec Streams Commission. This included the operation of various hydrometric stations in different parts of the province, a number having been recently added on tributaries of the Ottawa river in connection with the important development of this district, and along with the other stations maintained to further the wise utilization of the bountiful water-power potentialities of Quebec.

ORGANIZATION

The work in Quebec is directed from the District Chief Engineer's office at 201 Inspector street, Montreal, close co-operation being maintained with the Quebec Streams Commission whose head office is located in the same city.

CO-OPERATION

The investigations are pursued in well defined co-operation with the Quebec Streams Commission, but, in addition to this, many private organizations interested in the data secured lend most beneficial assistance by co-operating in the various activities of the service in Quebec. Among the latter organizations may be mentioned the Shawinigan Water and Power Company; Duke-Price Power Company; Price Brothers, Limited; Canadian International Paper Company; Laurentide Power Company; Southern Canada Power Company; Ottawa-Montreal Power Company; Quebec Power Company, and the Lower St. Lawrence Power Company.

HYDROMETRIC SURVEY

During the fiscal year ended March 31, 1927, 88 gauging stations were maintained on rivers and lakes in the following main watersheds: Ottawa, St. Maurice, St. François, Richelieu, Batiscan, Jacques-Cartier and Chaudière rivers, other northern and southern tributaries of the Middle and Lower St. Lawrence, and the Saguenay, Nottaway and Harricana rivers. Of these 59 are all-year discharge record stations, one is operated for discharge records during the open season only and 28 are operated all year for the observation of water levels only; of the total 7 are for storage regulation, 74 others are maintained for power and 7 for both flood and power studies; in addition to these, miscel-

laneous measurements were obtained at 21 other points. The increase in the number of stations is mainly due to the extension of activities to several tributaries of the Ottawa river. Although following a mild winter the spring of 1926 was late and cold with the result that April and in some cases May run-offs were below normal; the late freshets, however, made up for the early deficiency and were above normal except on the St. Maurice, whose waters were held back by the Gouin dam for storage purposes. The summer run-offs were evidently increased by the effect of this late spring, as, although the precipitation was comparatively low, the stream-flow was almost up to, and in some cases above, normal. Early autumn was marked by light rainfall and consequent slightly sub-normal run-offs, while heavy November precipitation generally brought these up to above normal.

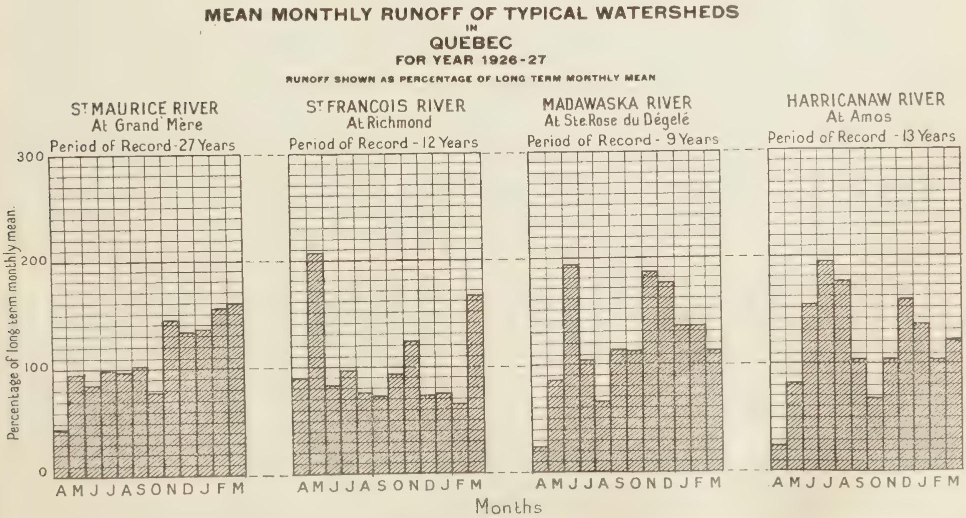
The comparatively mild winter continued to produce above normal run-offs except in the Eastern Townships where they were below normal for the first two months of 1927, but rose to 64 per cent above normal for March.

During the fiscal year the temperature ruled below average and a compilation from the records of 7 representative stations distributed over the province gave a mean yearly temperature for the year one degree below the average.

For the purpose of illustrating the general run-off conditions in Quebec, graphs showing the variation from the mean, month by month, for four typical stations have been prepared and are attached (see plate 6). The stations selected for this province are the St. Maurice river at Grand'mère, the St. François river at Richmond, the Madawaska river at Ste. Rose Degele, and the Harricana river at Amos.

To the north of the Middle St. Lawrence, as typified by the St. Maurice river, precipitation was below normal and the run-off for the year was 98 per cent of the long-term mean. Flood run-off reached a maximum daily discharge of 7·0 second-feet per square mile in May as compared with 10·7 second-feet per square mile, the maximum for the period of record. The low run-off which occurred in September was at the rate of 0·86 second-foot per square mile as compared with 0·20 second-foot per square mile, the lowest so far recorded.

PLATE 6



For the southern portion of the province the typical stream selected is the St. François river. The precipitation was below the average but the run-off for the year was 114 per cent of the long-term mean. Flood run-off reached a maximum daily discharge of 15·7 second-feet per square mile in April as compared with 18·1 second-feet per square mile, the maximum hitherto recorded. The low run-off which occurred in August was at the rate of 0.47 second-foot per square mile as compared with 0·22 second-foot per square mile, the lowest on record.

For the eastern portion of the province, south of the St. Lawrence, the typical stream selected is the Madawaska river. The precipitation was above the average and the run-off for the year was 114 per cent of the long-term mean. Flood run-off reached a maximum daily discharge of 10·3 second-feet per square mile in May, nearly equalling the maximum so far recorded of 10·8 second-feet per square mile. The low run-off which occurred in April was at the rate of 0·33 second-foot per square mile, as compared with 0·05 second-foot per square mile, the lowest so far recorded.

For the northern portion of the province, the typical stream selected is the Harricana river. The precipitation was above normal and the run-off for the year was 112 per cent of the long-term mean. Flood run-off reached a maximum daily discharge of 5·2 second-feet per square mile in May as compared with 6·6 second-feet per square mile, the maximum for the period of record. The low run-off which occurred in March was at the rate of 0·31 second-foot per square mile as compared with 0·20 second-foot per square mile, the lowest so far recorded.

SPECIAL INVESTIGATIONS

Work was continued on securing, classifying and summarizing in proper form all available data from various sources on developed and undeveloped water-power in Quebec province. These data cover particularly all surveyed or explored rivers of the province and are extensively used in satisfying numerous requests for information in connection with proposed or existing power developments and industrial expansion. This material is also used in connection with the Water Power Resources Inventory including the preparation of power river synopses.

The water levels and flow investigation of Prairies river near Montreal was continued throughout the year, while a number of special meterings were made on the St. Maurice to check the regulation of this river.

During the year a complete reanalysis of data in connection with developed and un-developed water-power in Quebec was carried on in close co-operation with the Quebec Streams Commission and, resulting therefrom, the work of compiling a list of water-powers in the province was undertaken and was brought to completion during the month of March. The list was thereupon submitted to the Quebec Streams Commission for review, following which the matter of publication will rest with the provincial authorities.

DISTRICT OF THE MARITIME PROVINCES

K. G. Chisholm, District Chief Engineer

The activities of the Water Power and Reclamation Service in the Maritime Provinces were continued during the fiscal year ended March 31, 1927, in conformity with the agreements of 1919 between the Minister of the Interior on behalf of the Federal Government, and the Governments of Nova Scotia, New Brunswick, and Prince Edward Island.

ORGANIZATION

The district office is centrally situated at 193 Hollis street, Halifax, from which point all parts of the district are readily accessible and branch offices are not required. Office accommodation is provided by the Nova Scotia Government.

The primary duty of the organization is the systematic collection and analysis of stream-flow data which is making possible a scientific study of the water resources of the district, and has already had a marked effect on water-power development. Secondary to this important work is a routine system of investigatory surveys of all important power and storage possibilities.

By the terms of the agreements under which the service operates the closest co-operation is maintained with the local governments and every possible assistance given to their departments, the Nova Scotia Power Commission and the New Brunswick Electric Power Commission, actively engaged in the development and distribution of power. By reason of the fundamental stream-flow data on which all water-power projects are directly dependent and the accumulation of information relating to particular rivers and sites, the department has been in close touch with practically every modern water-power development in the Maritime Provinces.

HYDROMETRIC SURVEY

Stream gauging was under way at 35 regular gauging stations, of which 3 were discontinued during the year owing to unsatisfactory conditions of control. Of the 32 permanent stations under observation at the end of the year, 9 are in New Brunswick, 19 in Nova Scotia, and 3 in Prince Edward Island. In practically every case the rivers now under observation in New Brunswick and Nova Scotia are important power streams, and in addition are so distributed as to give added value to the records for comparative estimates of power and flow on other streams. In Prince Edward Island there are no large power sites and the three gauging stations maintained are valuable only for statistical purposes in estimates of power supply.

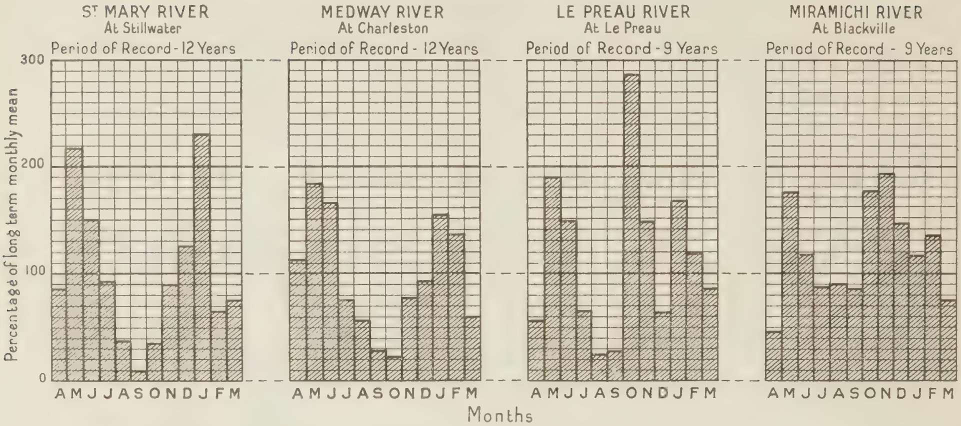
The mean yearly run-off was above normal in all parts of the district owing chiefly to unusual climatic conditions at two different periods of the year. The spring of 1926 was exceptionally late throughout the whole district so that spring freshets were delayed into May and June, and the winter months of December, 1926, and January, 1927, were generally mild and rainy with consequent high water for those months also over most of the district. Notwithstanding droughts more or less severe during the late summer and early fall the net result for the year was mean figures varying from 110 per cent to 123 per cent of the long term average.

In presenting a summary of the above-mentioned conditions the run-off on four different streams typical of as many parts of the district is shown graphically on Plate 7.

In eastern Nova Scotia, typified by the St. Mary river, the mean run-off for the year was 115 per cent of the average for the past twelve years. The sub-normal flow in April and the high water of May and June consequent upon the delay in the spring freshets are evident. A low water period extended from July to November with a minimum in September, when the monthly mean was only 9 per cent of the average, and was followed by high water in December and January. During the September drought low flows of 0·07 second-foot per square mile were recorded as compared with an absolute minimum of 0·04 second-foot in 1921. In February and March sub-normal flows again occurred owing to cold weather in those months.

PLATE 7

MEAN MONTHLY RUNOFF OF TYPICAL WATERSHEDS IN THE MARITIME PROVINCES
FOR YEAR 1926-27
RUNOFF SHOWN AS PERCENTAGE OF LONG TERM MONTHLY MEAN



On the Medway river in southwestern Nova Scotia, where the yearly mean was 110 per cent of the average, the run-off was very similar throughout the year to that of the St. Mary river except that the streams in this portion of the district having much greater lake areas, the extremes of high and low water were not so pronounced. No very large floods occurred and the minimum flow for the year was 0·19 second-foot per square mile, whereas flows of 0·04 second-foot per square mile occurred in 1921.

In southern New Brunswick, as shown by Lepreau River records, conditions in the spring and early summer of 1926, and in the winter of 1926-27 followed quite closely those of the St. Mary and Medway rivers in Nova Scotia. During the months of October and November, however, heavy rains resulted in high water with floods of 55 second-feet per square mile on October 25 and 26. The minimum flow during the year was over five times the record low flow of 1921 and the yearly mean was 116 per cent of the long-term average.

The Miramichi has been selected as characteristic of the run-off in northern New Brunswick. Following the spring floods of May and June the stream-flow for July, August, and September dropped to little below normal. During October, November, and December there were frequent rains and the streams remained fairly high until cold weather in the latter part of February and early in March caused sub-normal flows of 76 per cent for the month of March. The mean for the year was 123 per cent of the average for the past nine years and no record maximum or minimum occurred.

SPECIAL INVESTIGATIONS

Under the routine inquiry into power resources of the district, the Gaspereau river in Nova Scotia was investigated in considerable detail. This is one of the chief power streams in Nova Scotia and is of special importance by reason of its control by the Nova Scotia Tramways and Power Company, operating the power and lighting system in the city of Halifax. On several occasions development has been projected to supply the Halifax load and early in 1926 when it again became active a complete investigation by this service was requested. Notwithstanding previous preliminary work from

other sources this investigation, which was not completed until the middle of August, established for the first time data indispensable to a comprehensive study of the power possibilities of the river and which constitute an important addition to the knowledge of the water-power resources of Nova Scotia.

During the year a comprehensive examination of the Nipisiguit river in connection with proposed large increases in the supply of power to the pulp and paper industry at Bathurst was made. During these investigations very considerable assistance was rendered by officials of the Water Power and Reclamation Service, in the preliminary storage reconnaissance, in the detailed surveys of the various power sites already indicated by preliminary investigations of the service in 1922, and in the supply of hydrometric records from which power estimates could be made.

The outstanding construction event of the year in this district was the opening of work at the Grand Falls development of the St. John river, New Brunswick, on August 10. This service has been in close touch with this project since its early stages in 1923, both in regard to international questions involved and in detailed preliminary investigations.

Dependent to a certain extent on the Grand Falls development is the project of the New Brunswick Electric Power Commission for development at Meductic Falls further down stream. This will be a variable head development and this service was able to supply daily observations of gauge height and discharge for the past eight years, from which the fluctuations of head and flow, the possible power output and, in connection with cost estimates prepared by the commission, the economic feasibility or otherwise of the site may be definitely established. This project is still under investigation.

In Nova Scotia, the 5,000-hp. extension to the St. Margaret Bay system of the Nova Scotia Power Commission was actively commenced early in February. In accordance with the co-operative nature of the department's activities in this district as much assistance as possible was given to the commission and certain items of design were handled in this office.

At the request of both the New Brunswick Electric Power Commission and engineers acting for the International Paper Company at Grand Falls, a reconnaissance was made of portions of the Miramichi river in New Brunswick, and further surveying completed at the White Rapids site on the main southwest branch.

On the St. Croix river, forming part of the international boundary between New Brunswick and the state of Maine, the regulation of the flow past the Grand Falls power dam of the St. Croix Paper Company in the interests of power users on both sides of the river, and the maintenance of proper fishway facilities are subject to the supervision of the International St. Croix Board of Control, of which the director of this service is Canadian member. An inspection of the river and a report thereon was made from this office in November, 1926.

In December an inspection and timber estimate of 180 acres of land at Shelburne, N.S., was made for the Ordnance Admiralty and Railway Lands Branch of the department.

At the request of the Nova Scotia Power Commission and the town of Hawkesbury, an investigation was made of Horton brook as a possible source of power supply for the town.

In addition to the above definite items, a large number of inquiries were adequately dealt with from hydrometric and other data on file.

PART III

RECLAMATION

IRRIGATION

J. S. Tempest, Commissioner of Irrigation

General

The very light snowfall of the winter 1925-26 and the subnormal precipitation in the central and southern portions of the provinces of Alberta and Saskatchewan caused a shortage of water both for irrigation and domestic purposes, resulting in a number of complaints which were investigated and satisfactorily adjusted.

Throughout the semi-arid section and in the Peace River area settlers are becoming more alive to the value of an improved water supply. Dams are being constructed throughout these areas with sufficient storage capacity to ensure an adequate reservoir supply. In many cases, due to ignorance of the law, these dams have been constructed without authority and have only been brought to the attention of the department through complaints regarding the amount of available water further down stream.

In response to requests from irrigation districts and in rendering advice to individual irrigators, field work on the location of farm laterals was again carried out together with investigations into soil conditions under irrigation. Studies of seepage and alkali problems were continued on the larger projects throughout the season. The value of these studies will probably not be apparent till their completion when a very large amount of data will be available.

The classification of irrigable lands was continued throughout the season by one engineer and helper, both of whom have been fully occupied during the winter months in co-ordinating, tabulating and mapping the data collected.

Investigations were continued at the Brooks "Duty of Water" Experiment Station and a large amount of very useful information gained. Co-operative work in the study of the kernel quality of wheat in relation to irrigation was continued with the University of Alberta and three years' data are now available.

The sugar beet industry is developing into an important factor in the agricultural life of the settler on irrigated lands within an economic radius of the factory at Raymond. The improvement in the condition of the lands devoted to the growing of sugar beet, due to the necessity of intensive cultivation, is already becoming apparent. The demand for the results of our investigation of the water requirements of this crop is evidence of the great interest being taken by the farmers in the successful cultivation of the sugar beet, on varying soil types, under irrigation.

Water Administration

During the calendar year 1926, 77 applications were filed for the right to use water under the Irrigation Act, an increase of 14 over the previous year. There were at the end of the year 1,277 licensed or authorized projects, in various stages of completion, while 216 proposed projects were under investigation.

Stream-flow Estimates

Maps have been completed showing lines of equal mean, maximum and minimum run-off in Alberta and Saskatchewan. These graphic respresentations of water-supply conditions are deduced from hydrometric records to September, 1925, and their preparation has involved a considerable volume of original research in determining co-efficients to reduce all data to a common basis The methods adopted are of special value in estimating unmeasured water supplies and obtaining a broad view of the hydrometric situation from time to time.

Meteorological Information

Records of precipitation, temperature, relative humidity and wind velocities have been tabulated from the monthly reports of the meteorological service and studies are being continued to determine the climatic factors which affect the hydrological and crop growth conditions in the irrigated areas. Comprehensive data of this nature are necessary in dealing with applications and protests, in order to distinguish between the effect of natural and artificial control of lakes, flooded areas and streams. It is often difficult to convince those interested that effects due to the ordinary climatic cycles are not the result of works constructed under authority of the Irrigation Act, and studies based on independent observations are especially valuable in this connection.

Evaporation

In estimating losses from lakes and reservoirs, evaporation is usually the principal factor and fairly close estimates are necessary in designing reservoirs or utilizing lake records for hydrological studies. Losses from land surfaces bear a general relation to similar losses from water surfaces and affect the relation of run-off to precipitation. While it is generally known that low evaporation is a large contributor to the productivity of Western Canada, more definite collated data are desirable in connection with the duty of water as applied to different localities.

Observations have been taken in metal tanks at various times and places since 1896. The summer records at the University of Saskatchewan at Saskatoon are fairly complete from 1918 to date and can be compared with Class I, meteorological data, so that it has been possible to devise a formula for the purpose of estimating evaporation from the published weather reports. A judicious use of this method will add considerably to the knowledge of the evaporation to be expected under various conditions, and will enable the service to complete and supplement the information obtained by direct observation.

INTERNATIONAL STREAMS ADMINISTRATION

The measurement and apportionment of the waters of the St. Mary and Milk rivers was carried out during the past season under the provisions of the order of the International Joint Commission of the 4th October, 1921. The same pleasant relations continued with the Montana division of the United States Geological Survey and with the United States Bureau of Reclamation in the co-operative collection of the stream-flow data on the international streams flowing in Montana, Saskatchewan, and Alberta.

The flow of these streams and their tributaries during the irrigation season of 1926 was one of the lowest on record and the demand for water for irrigation purposes was the greatest experienced. While the water supply was insufficient to fulfil all demands, the irrigated areas depending upon the main streams for their supply did not suffer seriously.

The investigation of snow conditions in the Upper St. Mary river basin was continued early in May and carried out jointly with the Montana division of the United States Geological Survey. By these investigations the relationship between depth of snow and run-off from the area is fairly well established.

INSPECTION WORK

The investigation of proposed projects involving the making of surveys and the preparation of plans was continued throughout the field season in conjunction with canal and stream measurements and the study of absorption losses in reservoirs. Wherever possible, schemes in operation were also inspected. The following is a summary of work carried out in each district:—

District	Gauging Stations	Inspections	Surveys	Gaugings
South Saskatchewan	9	32	11	74
North Saskatchewan	13	27	1	77
Boundary	64	48	10	312
Medicine Hat	36	64	11	167
Calgary	14	22	3	125
Lethbridge and Vauxhall	15	23	4	130
Cardston	34	22	6	282
Macleod	15	56	6	158
Banff	24	9	4	227
Edmonton	12	34	6	71
North Alberta	19	50	11	136
Totals	255	387	73	1,759

Inspection work for the season was mostly of a routine nature, the only unusual feature being complaints requiring investigation. The striking point about these complaints was not the fact that they were more numerous than usual, but that they were received from localities which seldom, if ever, before have suffered a shortage of water for the ordinary domestic and stock-watering requirements of the settlers. This was particularly noticeable in the southwestern part of the province extending into the foot-hill country.

Watermasters.—New watermaster warrants were issued early in 1926 to conform to the new district boundaries in the southern part of the provinces of Alberta and Saskatchewan. This area, previous to the amalgamation of the Reclamation Service with the Water Power Branch, was divided into three inspection districts, but is now divided into six, viz: Macleod, Cardston, Lethbridge, and Medicine Hat districts in Alberta; Boundary and South Saskatchewan districts in Saskatchewan. In consequence the watermaster warrants were increased to six, one to the engineer in charge of each district. As noted above, a number of complaints were investigated and all were settled promptly by the watermasters concerned. Only one was of a serious nature, that received from a number of settlers along Etzikom coulee in the Lethbridge district, due to a shortage of water for stock-watering purposes. The watermaster by vigorous action and the exercise of a considerable amount of tact in dealing with owners of reservoirs in the coulee was able to effect prompt relief of what might very soon have developed into a serious situation.

Domestic Water Supplies.—As in previous years, many applications for the right to impound water for domestic purposes were dealt with. Although the works connected with such applications are generally insignificant from the standpoint of their extent and cost, nevertheless their importance to settlers in areas where there are no perennial streams is obviously very great. To obtain

a water supply to meet their domestic and stock-watering requirements, these settlers must conserve what run-off occurs and the common method in practice is to dam a convenient coulee or watercourse by an earthen embankment, with a ditch around one (or each) end of the dam to provide for the passage of flood water. This type of dam calls for no cash outlay, an item of great importance to the average farmer, and if proper care is taken in design and construction, is admirably suited to the purpose. The inspecting engineers are ready at all times to lend their services to the settlers in their respective districts in the laying out of their works and to advise them regarding construction problems. Whenever unauthorized works of this kind are encountered the owners are advised to protect their interests by taking the proper steps to have them legalized.

Municipal Water Consumption Data.—These data have been collected for a number of years and the records compiled therefrom are submitted in the tables appended. The department is indebted to the various towns and cities for their co-operation in furnishing the monthly records.

DROUGHT AREA INVESTIGATION

It is generally recognized that extensive areas in Alberta and Saskatchewan, where precipitation is insufficient for the growth of crops and where irrigation is not practised, may be used to the best advantage for grazing purposes and in an endeavour to find some solution applicable to the drought areas generally that portion of Alberta between the Red Deer and South Saskatchewan rivers to the east of range 11 has been investigated in some detail. In the year 1924 a survey was made of this area and a report completed having regard primarily to the available water supplies and suitability of the lands for grazing purposes. While it was found that the present stock-water supplies, consisting of rivers, springs and sloughs are sufficient for the larger portion of the area, there are a number of townships which can only be served by artificial means. A further field investigation was carried out during the past year for the purpose of determining ways and means for improving the water-supply conditions in these townships, mainly by the location of sites for small earth dams in coulees where a portion of the run-off may be impounded. In connection with this work sixty-six possible sites were investigated and surveys and cost estimates completed.

In addition to the above work, investigations were made to determine the possibilities of improving the water-supply conditions by an extension of the canal system of either the Canadian Pacific Railway Company or the Canada Land and Irrigation Company. It was found that the cost of either of these schemes would be excessive and that the present supplies could be more economically improved by the construction of small reservoirs and wells.

Major Irrigation Projects

THE CANADIAN PACIFIC RAILWAY COMPANY

Western Section.—Water was turned into the system on April 30 and the headgates closed on September 19. During the year, 125,176 acre-feet of water were diverted from the Bow river. The highest daily discharge recorded was 1,040 cubic feet per second on June 6, and the average daily flow for the month of maximum demand was 627 cubic feet per second during July.

During the past season 19,561 acres were actually irrigated, an increase over 1925 of 14,177 acres. The total cropped irrigable area was 187,600 acres producing values amounting to $3,719,208, or representing a per acre return of $18.38. Of the total cropped area on water-right land 158,500 acres were in

wheat, which produced 2,870,000 bushels or at the rate of 18 bushels per acre. Other crops on water-right lands included: oats, 20,000 acres; barley, 5,000 acres; hay crops, 17,000 acres.

The season was generally favourable, precipitation being slightly above the average of the past fourteen years. Spring conditions were promising with plenty of reserve moisture in the soil. Unfortunately, however, the month of September brought early snow storms and frost which, together, did considerable damage to all late seeded crops as well as to grain in stook.

Cities and Towns in the province of Alberta—Record of Daily Water Consumption in Imperial Gallons for the Year 1926

Month	Athabaska—Population 450						Bassano—Population 1,000					
	Daily Average for the month	Per Head for domestic purposes	Per Head for industrial purposes	Per Head for other purposes	Per Head for all purposes	Unaccounted for	Daily average for the month	Per Head for domestic purposes	Per Head for industrial purposes	Per Head for other purposes	Per Head for all purposes	Unaccounted for
January	3,000	6·7	....	....	6·7	....	122,258	....	....	....	122·3	....
February	3,321	7·4	....	....	7·4	....	116,428	....	....	....	116·4	....
March	3,000	6·7	....	....	6·7	....	129,355	....	....	....	129·4	....
April	3,000	6·7	....	....	6·7	....	160,666	....	....	....	160·7	....
May	3,064	6·8	....	....	6·8	....	199,516	....	....	....	199·5	....
June	3,000	6·7	....	....	6·7	....	210,166	....	....	....	210·2	....
July	3,064	6·8	....	....	6·8	....	241,290	....	....	....	241·3	....
August	3,064	6·8	....	....	6·8	....	213,871	....	....	....	213·9	....
September	3,267	7·3	....	....	7·3	....	184,667	....	....	....	184·7	....
October	3,161	7·0	....	....	7·0	....	173,871	....	....	....	173·9	....
November	3,300	7·3	....	....	7·3	....	176,000	....	....	....	176·0	....
December	6,427	14·3	....	....	14·3	....	165,000	....	....	....	165·0	....
Average for the year	3,389	7·5	....	....	7·5	....	174,424	....	....	....	174·4	....

Month	Edmonton—Population 65,000						Lethbridge—Population 13,000					
January	5,772,903	51·5	22·2	15·1	88·8	....	1,252,838	64·6	31·8	....	96·4	....
February	5,835,000	52·1	22·4	15·3	89·8	....	1,222,321	62·1	31·9	....	94·0	....
March	5,783,226	51·6	22·2	15·1	88·9	....	1,167,935	62·8	27·0	....	89·8	....
April	6,006,667	53·6	23·1	15·7	92·4	....	1,437,700	71·2	39·1	0·3	110·6	....
May	6,251,613	55·8	24·0	16·4	96·2	....	1,857,387	102·9	35·9	4·1	142·9	....
June	6,182,333	55·1	23·8	16·2	95·1	....	1,890,200	100·6	40·0	4·8	145·4	....
July	7,163,226	63·9	27·6	18·7	110·2	....	2,079,000	106·4	47·3	6·2	159·9	....
August	6,219,677	55·7	24·0	16·0	95·7	....	1,665,677	83·1	43·0	2·0	128·1	....
September	5,986,667	53·4	23·0	15·7	92·1	....	1,272,200	63·2	34·7	....	97·9	....
October	5,599,484	50·0	21·5	14·6	86·1	....	1,321,161	65·8	35·8	....	101·6	....
November	5,841,667	52·1	22·5	15·3	89·9	....	1,446,200	71·3	39·9	....	111·2	....
December	5,916,452	52·8	22·7	15·5	91·0	....	1,309,741	65·5	35·2	....	100·7	....
Average for the year	6,044,910	54·0	23·2	15·8	93·0	....	1,493,530	76·6	36·8	1·5	114·9	....

Month	Medicine Hat—Population 10,000						Redcliff—Population 1,000					
January	2,265,484	....	....	....	226·5	....	94,637	....	....	....	94·6	....
February	2,018,214	....	....	....	201·8	....	93,607	....	....	....	93·6	....
March	2,104,516	....	....	....	210·5	....	102,208	....	....	....	102·2	....
April	2,532,333	....	....	....	253·2	....	149,442	....	....	....	149·4	....
May	3,022,258	....	....	....	302·2	....	258,000	....	....	....	258·0	....
June	3,461,667	....	....	....	346·2	....	321,450	....	....	....	321·4	....
July	4,099,355	....	....	....	409·9	....	412,459	....	....	....	412·5	....
August	3,070,968	....	....	....	307·1	....	250,829	....	....	....	250·8	....
September	2,344,667	....	....	....	234·5	....	95,550	....	....	....	95·6	....
October	2,241,290	....	....	....	224·1	....	104,234	....	....	....	104·2	....
November	2,334,333	....	....	....	233·4	....	102,208	....	....	....	102·2	....
December	2,390,645	....	....	....	239·1	....	129,348	....	....	....	129·3	....
Average for the year	2,657,144	....	....	....	265·7	....	176,164	....	....	....	176·2	....

Cities and Towns in the province of Saskatchewan—Record of Daily Water Consumption in Imperial Gallons for the Year 1926.

Month	Estevan—Population 2,500						Moose Jaw—Population 21,000					
	Daily Average for month	Per Head for domestic purposes	Per Head for industrial purposes	Per Head for other purposes	Per Head for all purposes	Unaccounted for	Daily Average for month	Per Head for domestic purposes	Per Head for industrial purposes	Per Head for other purposes	Per Head for all purposes	Unaccounted for
January	47,645	....	....	....	19·1	....	882,484	33·4	8·6	....	42·0	....
February	43,429	....	....	....	17·4	....	919,107	33·8	10·0	....	43·8	....
March	66,194	....	....	....	26·5	....	1,057,839	34·4	16·0	....	50·4	....
April	41,783	....	....	....	16·7	....	1,066,533	41·4	9·4	....	50·8	....
May	42,750	....	....	....	17·1	....	993,548	33·9	13·4	....	47·3	....
June	47,375	....	....	....	18·9	....	1,020,033	33·9	14·7	....	48·6	....
July	57,242	....	....	....	22·9	....	1,138,258	38·2	16·0	....	54·2	....
August	53,153	....	....	....	21·3	....	1,016,581	30·9	17·5	....	48·4	....
September	48,375	....	....	....	19·3	....	918,300	27·2	16·5	....	43·7	....
October	45,823	....	....	....	18·3	....	921,355	29·1	14·8	....	43·9	....
November	51,400	....	....	....	20·6	....	1,019,167	30·9	17·6	....	48·5	....
December	58,056	....	....	....	23·2	....	994,387	30·7	16·6	....	47·3	....
Average for the year	50,269	....	....	....	20·1	....	995,633	33·1	14·3	....	47·4	....

Month	Weyburn—Population 4,000						Prince Albert—Population 8,000					
January	243,750	60·9	....	....	60·9	....	476,684	29·8	22·4	0·4	59·6	2·0
February	235,089	58·8	....	....	58·8	....	470,429	28·3	28·6	0·7	58·8	1·2
March	231,983	58·0	....	....	58·0	....	532,758	28·6	27·4	0·6	66·6	10·0
April	245,145	61·3	....	....	61·3	....	552,717	29·7	30·0	1·7	69·1	7·7
May	248,165	62·0	....	....	62·0	....	585,381	27·6	29·8	0·8	73·2	15·0
June	257,638	64·4	....	....	64·4	....	665,023	28·4	42·6	0·9	83·1	11·2
July	306,724	76·7	....	....	76·7	....	697,042	30·4	29·5	1·8	87·1	25·4
August	282,500	70·6	....	....	70·6	....	605,694	27·1	35·3	1·1	75·7	12·2
September	223,637	55·9	....	....	55·9	....	573,127	30·1	32·7	0·8	71·6	8·0
October	231,625	57·9	....	....	57·9	....	529,974	26·5	30·3	1·1	66·2	8·3
November	254,752	63·7	....	....	63·7	....	483,500	26·7	32·7	1·0	60·4	....
December	203,031	50·8	....	....	50·8	....	494,900	27·2	32·0	1·7	61·8	0·9
Average for the year	247,003	61·8	....	....	61·8	....	555,602	28·4	31·5	1·0	69·4	8·5

	North Battleford—Population 4,100						Kamsack—Population 380*					
January	83,252	10,6	1·0	5·2	20·3	3·5	196,855	22·3	255·4	5·4	518·1	235·0
February	98,636	11·1	1·1	4·3	24·6	7·6	176,593	17·9	254·1	38·4	464·7	154·3
March	125,158	9·7	0·9	2·6	30·5	17·3	130,765	19·3	114·1	2·2	344·1	208·5
April	136,497	10·6	1·4	2·2	33·3	19·1	125,230	21·4	106·7	5·0	329·5	196·4
May	152,400	11·4	2·0	2·0	37·2	21·8	160,013	39·4	163·7	4·0	421·1	214·0
June	163,890	12·3	2·4	4·6	40·0	20·7	135,807	28·9	184·6	3·9	357·4	140·0
July	159,803	13·3	3·9	2·5	39·0	19·3	104,461	27·6	154·7	8·2	274·9	190·4
August	137,390	13·7	4·6	0·9	33·5	14·3	83,600	36·1	102·5	5·1	220·0	76·3
September	99,683	13·4	3·0	2·7	24·3	5·2	80,047	31·0	159·9	3·2	210·6	16·5
October	109,329	9·9	1·3	3·0	26·7	12·5	82,381	24·8	136·2	0·8	216·8	55·0
November	128,593	12·9	2·9	3·0	31·4	12·6	135,663	26·4	268·0	0	352·0	62·5
December	127,458	11·4	3·4	6·6	31·1	9·7	115,377	22·8	229·8	....	303·6	51·0
Average for the year	126,841	11·7	2·3	3·3	30·9	13·6	127,233	26·5	177·5	6·4	334·8	133·4

*Only 76 consumers or approximately 380 persons supplied. This figure is used in computations, although population is about 2,000.

Cities and Towns in the province of Saskatchewan—Record of Daily Water Consumption in Imperial Gallons for the Year 1926.—Con.

Month	Regina—Population 37,100						Saskatoon—Population 31,000†					
Month	Daily Average for the month	Per Head for domestic purposes	Per Head for industrial purposes	Per Head for other purposes	Per Head for all purposes	Unaccounted for	Daily Average for the month	Per Head for domestic purposes	Per Head for industrial purposes	Per Head for other purposes	Per Head for all purposes	Unaccounted for
January	2,836,322	71·8	2·8	1·0	76·5	....	2,051,129					
February	2,898,018	72·8	3·9	1·4	78·1	....	2,013,750	28·5	17·1	0·5	65·6	19·5
March	2,786,300	70·2	3·7	1·2	75·1	....	2,033,226					
April	2,761,376	69·4	3·9	1·1	74·4	....	2,050,000					
May	2,843,226	70·9	4·2	1·5	76·6	....	2,197,097	30·0	16·0	3·5	71·4	21·9
June	3,055,529	75·6	5·5	1·3	82·4	....	2,396,333					
July	3,290,464	79·3	7·7	1·7	88·7	....	2,700,161					
August	3,063,969	74·6	6·5	1·5	82·6	....	2,553,871	31·2	17·3	5·9	81·3	26·9
September	2,915,797	72·2	5·1	1·3	78·6	....	2,298,166					
October	2,822,632	70·6	4·2	1·3	76·1	....	2,272,258					
November	2,714,027	66·5	5·0	1·7	73·2	....	2,417,000	28·1	20·9	1·4	73·6	23·2
December	2,817,826	70·2	4·4	1·4	76·0	....	2,162,903					
Average for the year	2,900,457	72·0	4·8	1·4	78·2	....	2,262,158	29·5	17·8	2·8	73·0	22·9

Month	Kindersley—Population 1,000					
January	4,887	4·9	....	....	4·9	....
February	8,769	8·8	....	....	8·8	....
March	8,561	8·6	....	....	8·6	....
April	9,634	9·6	....	....	9·6	....
May	9,688	9·7	....	....	9·7	....
June	13,693	13·7	....	....	13·7	....
July	18,987	19·0	....	....	19·0	....
Aug	10,657	10·7	....	....	10·7	....
Sept	10,263	10·3	....	....	10·3	....
October	8,514	8·5	....	....	8·5	....
November	8,075	8·1	....	....	8·1	....
December	8,323	8·3	....	....	8·3	....
Average for the year	10,004	10·0	....	....	10·0	....

†Includes Town of Sutherland.

Cities and Towns in the Province of Alberta—Record of Average Daily Water Consumption in Imperial Gallons for Years 1915-1926

Average for Year	Per Head Domestic	Per Head Industrial	Per Head other purposes	Per Head all purposes	Unaccounted for	Per Head Domestic	Per Head Industrial	Per Head other purposes	Per Head all purposes	Unaccounted for
	Edmonton					Lethbridge				
1915	46·0	31·0	3·0	80·0		81·4	32·2	1·5	115·1	
1916	52·5	20·7	5·7	78·9		116·0	41·3	0·7	158·0	
1917	56·3	25·0	9·7	31·0		95·0	55·0		150·0	
1918	58·0	26·2	10·1	94·3		102·2	44·7	3·0	149·9	
1919	56·7	24·6	9·7	91·7		78·1	26·9		107·3	
1920	54·7	23·4	16·2	94·3		91·8	35·1	6·8	129·1	
1921	54·6	23·4	16·8	94·8		94·2	27·8	1·4	123·4	
1922	62·2	24·9	24·1	111·1		110·8	33·5		145·1	
1923	53·5	22·4	13·5	89·4		96·0	35·4	0·7	132·1	
1924	55·0	23·7	15·7	94·4		88·8	36·8	1·4	127·0	
1925	54·1	23·3	15·8	93·2		74·7	35·0	0·8	110·5	
1926	54·0	23·2	15·8	93·0		76·6	36·8	1·5	114·9	
	Bassano					Carmangay				
1915	6·5	60·2		66·7		41·9		2·0	43·9	
1916						32·6			32·6	
1917	17·9	154·3	95·4	267·6		31·3			31·3	
1918				211·0		29·8		1·0	30·8	
1919				194·7		32·5		1·2	33·7	
1920				158·9		26·2		3·4	30·3	
1921				137·8						
1922				135·7						
1923				150·8				No records		
1924				176·8						
1925				178·0						
1926				174·4						
	Medicine Hat					Redcliffe				
1915	181·0	28·0	15·0	224·0		31·1	0·8		37·9	
1916				214·0		36·8	22·1	1·0	59·9	
1917				257·0		42·5	30·3		72·8	
1918				264·0		66·4	22·4		88·8	
1919				234·0		79·1	13·7		92·8	
1920				206·8		67·9	16·2		84·2	
1921				175·3		65·7	9·6	0·5	75·8	
1922				187·9		97·9	7·8		105·6	
1923				213·4		82·9	8·1		91·0*	
1924				222·2		136·6	8·4		145·0	
1925				252·3					143·4	
1926				265·7					176·2	
	Athabaska									
1915						14·3			14·3	
1916						10·9			10·9	
1917						24·0			24·0	
1918						27·6			27·6	
1919						26·1			26·1	
1920						44·3			44·3	
1921						33·3			33·3	
1922										
1923										
1924						18·0		0·2	18·2	
1925						19·1			19·1	
1926						7·5			7·5	

*Based on 4 months records.

Cities and Towns in the Province of Saskatchewan—Record of Average Daily Water Consumption in Imperial Gallons for Years 1915-1926

Average for year	Per Head for domestic purposes	Per Head for industrial purposes	Per Head for other purposes	Per Head for all purposes	Unaccounted for	Per Head for domestic purposes	Per Head for industrial purposes	Per Head for other purposes	Per Head for all purposes	Unaccounted for
	Regina					Saskatoon				
1915..........	55·0	7·5	0·1	62·6	....	21·6	13·9	2·2	45·6	7·9
1916..........	66·1	7·8	....	73·9	....	21·0	15·4	1·9	52·6	14·3
1917..........	59·2	12·6	0·3	72·1	....	24·4	15·6	5·8	66·4	20·6
1918..........	56·9	11·1	0·1	68·1	....	27·1	17·2	2·4	63·1	16·4
1919..........	42·8	8·3	....	51·2	....	28·0	16·3	1·9	64·1	17·9
1920..........	48·9	9·1	0·9*	58·8	....	29·4	14·3	6·1	74·1	24·4
1921..........	49·6	10·1	2·1	62·6	0·8	29·5	20·3	1·1	72·1	21·2
1922..........	59·2	12·6	2·5	74·5	....	31·0	23·6	1·5	78·4	22·4
1923..........	61·7	14·5	2·0	78·2	....	28·8	20·8	1·5	71·0	23·1
1924..........	65·1	9·7	1·5	76·7	0·4	27·9	19·2	2·4	69·3	19·8
1925..........	72·1	4·4	1·5	78·0	....	31·4	20·5	3·0	81·0	26·1
1916..........	72·0	4·8	1·4	78·2	....	29·5	17·8	2·8	73·0	22·9
	Weyburn					Kindersley				
1915..........	17·4	....	0·4	17·8	....	4·9	8·4	1·6	14·9	....
1916..........	16·9	....	0·3	17·2	....	5·5	26·8	....	32·3	....
1917..........	30·1	....	....	30·1	....	5·8	44·4	....	50·2	....
1918..........	26·4	....	....	26·4	....	6·0	8·9	....	14·9	....
1919..........	25·5	....	....	25·5	....	7·8	....	....	7·8	....
1920..........	30·2	....	....	30·2	....	6·9	17·5	....	21·5	....
1921..........	27·1	....	....	27·1	....	8·5	11·0	....	19·5	....
1922..........	....	....	....	64·4	....	10·1	12·3	....	22·4	....
1923..........	....	....	....	68·0	....	11·5	....	....	11·5	....
1924..........	....	....	....	77·4	....	11·0	....	....	11·0	....
1925..........	....	....	....	64·1	....	6·4	....	....	6·4	....
1926..........	61·8	....	....	61·8	....	....	....	....	....	....
	Moose Jaw					North Battleford				
1915..........	24·1	4·6	....	28·7	....	6·6	1·3	2·7	14·8	4·2
1916..........	35·2	12·3	....	47·5	....	9·5	2·0	4·9	22·7	6·3
1917..........	45·8	13·1	....	58·9	....	10·2	2·2	4·0	23·1	6·7
1918..........	31·6	15·4	....	47·0	....	10·0	4·8	3·0	26·3	8·5
1919..........	24·8	15·1	....	39·9	....	11·5	1·6	4·4	29·7	12·2
1920..........	24·5	14·5	....	39·1	....	11·3	5·8	5·9	34·0	10·9
1921..........	30·9	3·9	6·2	41·0	....	9·7	2·8	2·9	26·7	11·3
1922..........	34·8	9·0	....	43·8	....	11·0	2·8	4·3	34·1	15·9
1923..........	34·9	9·4	....	44·3	....	11·3	1·6	4·4	25·0	7·7
1924..........	36·5	8·0	....	44·5	....	10·8	2·3	3·7	33·4	16·6
1925..........	33·0	9·7	....	42·7	....	11·0	1·8	4·9	31·8	14·1
1926..........	33·1	14·3	....	47·4	....	11·7	2·3	3·3	30·9	13·6
	Kamsack					Prince Albert				
1915..........	....	....	....	....	....	....	....	....	....	....
1916..........	....	....	....	....	....	....	....	....	....	....
1917..........	....	....	....	....	....	....	....	....	....	....
1918..........	31·6	66·3	....	97·9	....	....	....	....	....	....
1919..........	....	....	....	....	....	....	....	....	....	....
1920..........	....	....	....	....	....	....	....	....	....	....
1921..........	50·4	724·9	....	775·3	....	....	....	....	83·0	....
1922..........	50·3	690·2	....	740·6	....	20·4	23·2	1·9	69·6	20·1
1923..........	27·3	291·5	....	478·5	....	22·8	27·1	1·6	70·0	18·5
1924..........	24·8	94·4	....	394·2	....	24·2	28·7	1·5	65·4	11·0
1925..........	23·3	90·6	....	405·5	....	29·2	30·2	1·3	70·6	9·9
1926..........	26·5	77·5	6·4	334·8	133·4	28·4	31·5	1·0	69·4	8·5
					Estevan					
1915..........	....	....	....	....	....	9·5	7·1	1·5	18·1	....
1916..........	....	....	....	....	....	8·2	5·7	1·0	14·9	....
1917..........	....	....	....	....	....	9·7	5·5	4·3	19·5	....
1918..........	....	....	....	....	....	9·3	0·7	7·2	17·2	....
1919..........	....	....	....	....	....	9·6	2·9	....	12·5	....
1920..........	....	....	....	....	....	9·3	4·4	....	13·7	....
1921..........	....	....	....	....	....	6·1	4·7	2·0	12·8	....
1922..........	....	....	....	....	....	8·5	6·4	2·9	17·9	....
1923..........	....	....	....	....	....	8·6	10·8	1·4	20·3	....
1924..........	....	....	....	....	....	9·2	6·1	2·9	18·2	....
1925..........	....	....	....	....	....	....	....	....	16·8	....
1926..........	....	....	....	....	....	....	....	....	20·1	....

*10 months.

The period free from killing frosts covered 133 days, from May 7 to September 16, or two days longer than in 1925. The total precipitation recorded at the Canadian Pacific Railway Company's operating headquarters at Strathmore for the year was 17·57 inches. The average precipitation at Strathmore for the period 1913 to 1926 has been 14·80 inches.

The following table gives comparative precipitation and temperature records taken at Strathmore, Alberta during the past two years, together with the average for 13 years, for growing season only.

Month	Precipitation in inches		Mean average for 13 years at Strathmore	Mean temperatures degrees Fahr.	
	1925	1926		1925	1926
April	1·00	0·23	0·95	39·33	39·61
May	1·96	0·44	1·84	47·87	48·23
June	2·86	3·31	2·91	55·43	55·52
July	2·13	0·80	2·03	61·24	61·50
August	2·09	3·77	2·31	57·91	57·82
September	1·54	4·04	1·67	50·89	50·28

A very extensive maintenance program was undertaken during the past season and included the following:—

117 miles of ditches cleared out by mechanical excavators.
21 miles of ditches cleared out by team work.
386 timber structures repaired.
3 concrete structures repaired.
598 timber structures renewed.
118 new timber structures.

The estimated total yardage moved during the season was 205,305, of which 93,716 was done by D. N. R. Excavator, 59,279 by drag line and 52,310 by team. Treated and creosoted timber is now being extensively used in the renewal of the major structures.

The live stock situation in this section has much improved, the past winter being particularly mild and feed plentiful. Hog and sheep raising has been profitable and there are numerous evidences of an increased interest in these lines. As an evidence of prosperity amongst the farmers of this district it may be of interest to note that $118,000 was expended during the year on new buildings. The cropped area of the project was also increased by the breaking up of some 6,270 acres of new land.

An electrical power transmission line has been extended from Gleichen to Strathmore during the past season. The power is developed at the Horseshoe Bend dam south of Bassano and distributed to the towns of Bassano, Cluny, Gleichen and Strathmore.

Eastern Section.—Water was turned into the system on May 4, and the headgates closed on October 1. During the past season's operations 353,800 acre-feet of water were diverted from the Bow river. The highest daily discharge recorded was 1918 cubic-feet per second on June 19, and the average daily flow for the month of maximum demand was 1,640 cubic-feet per second during July.

During the past season some 74,401 acres were actually irrigated, an increase over 1925 of 1,407 acres. The total cropped area was 71,489 acres, which produced crop values amounting to $1,526,666 or representing a per acre

return of $21.35. Of some 5,325 acres of land cropped but not irrigated a per acre return of $11.04 was received. On the irrigated lands the area in wheat was 36,170 acres, which produced 762,060 bushels or at the rate of 21 bushels per acre. Other staple crops grown included: oats 8,850 acres yielding 28 bushels per acre, barley 4,690 acres yielding 26 bushles per acre, alfalfa 13,355 acres yielding 1.9 tons per acre.

During the months of April and May high winds caused some soil drifting, especially where the soil was light in texture. Many of the farmers started irrigating in May in order to retard damage to their seeded areas from this cause. Harvesting conditions during the month of August were not ideal and some losses were experienced particularly to hay crops due to discolouration and consequent loss in grade. During September persistent stormy weather accompanied by low temperatures prevailed almost throughout the entire month. Threshing operations were consequently held up until the end of September. During October conditions were very favourable and all crops were safely harvested. The few scattered plots of sugar beets in this project suffered from unseasonable weather after September 15. The period free from killing frost covered 135 days—from May 7 to September 19, or 10 days shorter than 1925. The total precipitation recorded at the Canadian Pacific Railway Company's operating headquarters at Brooks for the 12 months was 17·57 inches. The seasonal precipitation in inches as recorded at the Dominion Experimental station 2 miles west of Brooks is as follows: April, 0·19; May, 1·23; June, 1·53; July, 0·59; August, 2·06; September, 1·52; or equal to 7·12 inches.

Very little change in the live stock situation has taken place during the season with the exception of sheep where the increase has amounted to 100 per cent. Five carloads of horses were shipped to Russia from this district. Live stock shipments were as follows: Cattle, 5,800; horses, 2,700; sheep, 10,400; hogs, 8,900; turkeys, 2,500; wool, 311,400 pounds.

The maintenance program in this section included the following:—

125 miles of ditches cleared by mechanical excavators.
51 miles of ditches cleared by team work.
201 timber structures repaired.
180 timber structures renewed.
52 new timber structures.
20 concrete structures repaired.

Estimated total yardage moved during the season was 858,860, of which 586,430 cubic-yards was done by mechanical excavators and 272,430 cubic-yards by team.

Lethbridge Section.—The headworks located in section 36, township 1, range 25, west of the 4th meridian, were first constructed in 1899 and rebuilt during the winter of 1924-25. The new structure is a combination sluiceway and canal headworks and is built chiefly of creosoted timber, the only concrete used being in the downstream portion of the piers for the support of the gate lifting machinery. The system has now been in operation for 27 years, the first water being diverted in July, 1900.

At the close of the year 73,993 acres were held under water agreement as compared with 74,571 acres in 1925. In addition to this area the company has contracted to furnish water through their system for 6,800 irrigable acres in the newly created Raymond irrigation district and 5,100 for the Magrath irrigation district. The total irrigable area for which service will now be required is, therefore, 85,893 acres. There were 841 water users as compared with 803 in 1925. Water was turned into the system on April 15 and the headgates closed on October 19. During the period under operation 160,000 acre-feet of water were diverted from the St. Mary river. The highest daily discharge recorded

was 676 cubic-feet per second on June 9 and 10 and the average daily flow for the month of maximum demand was 539 cubic-feet per second during June. The area including leased land which received water during the season was 78,399 acres, the actual cropped area was 56,908 acres, which produced values amounting to $1,673,239 or representing a per acre return of $29.40. The major crop was wheat which represented 49 per cent of the total cropped area and produced an average yield valued at $27.50 per acre.

The total value and per acre value of the crops produced in 1926 was as follows:—

	Total value	Value per acre
From irrigated lands..	$2,075,739	$35.73
From non-irrigated lands..	174,836	18.41

Very little snow was received on the watershed of the St. Mary river during the winter 1925-26 and a shortage of water was anticipated. The water users in the district were, therefore, urged to irrigate early and as a result some 80 per cent of the lands under crop were irrigated by June 10.

The sugar beet acreage in the district was 4,170 acres, an increase of 1,080 acres over 1925. The average yield was 7·16 tons per acre and the saccharine content 16·49 per cent. The Raymond sugar factory sliced some 36,000 tons of beet and manufactured some 10,000,000 pounds of sugar. The average price paid to growers was $7 per ton.

Unfavourable weather during September caused some damage to both alfalfa hay and grain crops and harvesting operations were thereby delayed. Good weather throughout October, however, afforded ample opportunity for harvesting and threshing operations and the serious losses anticipated during September were greatly reduced.

The period free from damaging frosts extended from May 7 to September 15, or 132 days as compared with 145 days in 1925. The total precipitation recorded at Lethbridge during the year was 16·22 inches and the seasonal precipitation 13·73 inches made up as follows: April, 0·34; May, 0·64; June, 4·67; July, 1·15; August, 2·31; September, 4·62. The average monthly precipitation at Lethbridge for the past 25 years is as follows: January, 0·64; February, 0·65; March, 0·70; April, 0·93; May, 2·39; June, 2·82; July, 1·81; August, 1·76; September, 1·76; October, 0·84; November, 0·59; December, 0·62.

The maintenance program included:

33 miles of ditches cleared out by mechanical excavators, representing a total of some 40,000 cubic-yards of material.

1·64 miles by Austin drag line on Mallory drainage ditch, a total of 10,000 cubic-yards of material.

2 new concrete headgates for Magrath irrigation district.

Completion of chute on main canal near Spring Coulee.

9 small structures on Mallory drainage ditch.

45 miscellaneous small timber structures constructed.

TABER IRRIGATION DISTRICT

This district receives its water supply from the St. Mary river through the works of the Canadian Pacific Railway Company's Lethbridge Section. The 1926 operating season was the sixth since construction. At the close of the year there were 16,939·7 acres of classified irrigable land within the district. The number of water users was 161, as compared with 144 in 1925 and 14,383 acres were irrigated, representing 84·9 per cent of the total irrigable area.

Water was turned into the system on May 6 and closed down for the year on November 18, some 27,600 acre-feet being diverted from the Chin coulee storage reservoir. The highest daily discharge recorded being 162 cubic-feet per second on June 15 and 16 and the average daily flow for July, the month of maximum use, was 145 cubic feet per second.

During the season 14,383 acres were irrigated, an increase over 1925 of 911 acres. The principal crop was wheat which represented 50·5 per cent of the cropped area on irrigated land. There was a small increase in the sugar beet area, 797 acres being devoted to this crop as compared with 752 in 1925. The average yield was 10·2 tons per acre and the sugar content averaged 16·49 per cent. Other crops on irrigated lands included oats 1,617 acres, barley 672 acres and alfalfa 2,119 acres. The farmers of this district have enjoyed a very satisfactory year.

Six years of irrigation operations indicate that the district has an annual surplus of water over its requirements. This surplus which is estimated at 7,650 acre-feet is due to portions of the irrigable lands being annually idle or non-irrigated and to the seepage losses in the canal system not being as great as originally anticipated. With a view to putting this surplus to beneficial use, steps have already been taken to change the content of the district by the inclusion of an area of school and privately owned lands, for the most part outside the present district. This matter will be submitted to a vote of the ratepayers of the district at an early date.

THE CANADA LAND AND IRRIGATION COMPANY'S PROJECT

This project diverts its water from the Bow river in section 31, township 21, range 25, west of the 4th meridian. There were some 530,250 acres of land originally acquired by the company, of which approximately 202,640 acres are irrigable.

Diversions from the Bow river to Lake McGregor reservoir were made from April 12 to August 30 when a violent rain storm caused the partial destruction of flume No. 2 and rendered the diversion canal useless. The structure was not replaced as the company desires to do away with the flume and cross the coulee on an embankment. This latter form of crossing involves a change in road location and the work is being held in abeyance pending authority from the province for the necessary changes in the location of the road which at present traverses the coulee. The reserve supply of water in Lake McGregor reservoir was sufficient to carry over the balance of the season and this early closing down of the diversion canal did not impair the continued supply of water to farm units. The Little Bow section of the main canal between the Lake McGregor and the Little Bow reservoirs was successfully operated from May 23 to September 22. The steel flume constructed in 1924 satisfactorily met the conditions for which it was planned. The supply canal from the Little Bow reservoir to the irrigable lands of the project was operated continuously from May 2 to October 26.

In the early spring a crop share agreement was put into effect as supplementary to the land contract which provided for land payments to be made out of a share of the crop grown by the purchaser. As a result of this arrangement over 10,000 acres were sold in the vicinity of Vauxhall, the major portion of which will be productive next season. These new sales made it necessary to construct lateral extensions at a cost of about $27,500.

The gross crop yield for this district was less in value than for the year 1925 because the grade of grain crops was materially lowered by protracted wet weather which began about the 20th August and extended throughout September. In addition, the wet weather prevented crops from ripening. These conditions combined to reduce the crop value from $35.03 in the preceding year to $29.01 per acre, from a total cropped area of 10,389 acres.

New construction was confined to lateral ditch extensions to enable water to be supplied in 1927 to the lands disposed of in 1926 and contiguous parcels. The extensions constructed serve a total of 11,520 acres of new lands. The work

involved the construction of 17·5 miles of new ditches with necessary structures, drops, checks, turnouts and culverts, and required 40,000 cubic yards of excavation and 190,465 f.b.m. of timber.

A considerable portion of the land sold in 1926 has already been broken and prepared for seeding and further land preparations are expected during the coming spring. In view of the extensions of the irrigated lands of the Western district, it is expected that, including the New West irrigation district approximately 23,000 acres of land will be irrigated in the Vauxhall area in 1927.

NEW WEST IRRIGATION DISTRICT

The water supply of this district is obtained from the Bow river through the works of the Canada Land and Irrigation Company. The point of diversion from the Company's main canal being in the northeast quarter of section 36, township 13, range 17, west of the fourth meridian. The district contains an irrigable area of 4,501 acres and has 26 water users. The area irrigated in 1926 was 3,426 acres or 76·1 per cent of the total irrigable area, a slight decrease from the 1925 area which represented 78·9 per cent of the total. The average per acre yield of wheat in 1926 was 21·4 bushels as compared with 20·6 bushels in 1925.

The bonded indebtedness of the district as at the close of the calendar year was $209,500, the amount expended on repairs $262.60 and the total cost of management $2,839.74. This district is in a satisfactory financial position and the farmers are now gradually improving their holdings and increasing their live stock.

LETHBRIDGE NORTHERN IRRIGATION DISTRICT

The total classified irrigable area as at the close of 1926 was 104,437 acres, of which 56,395 acres were irrigated during the past season as compared with 43,628 in 1925. The 1926 season was the third year of operation for this project and from a perusal of the crop returns received it would appear that very satisfactory progress is being made. Unfavourable conditions in the spring the result of high winds and dry weather, caused soil drifting in some sections which was the source of a great deal of expense to the district. This condition delayed germination of crops with the result that much of the crop, which would otherwise have ripened, was caught by the early frost. The major crop was wheat —742,198 bushels being produced from 35,078 acres, an average yield of 21·1 bushels. This area represented 76 per cent of the farmed irrigable land.

Good progress has been made during the year by the colonization organization created by the provincial government in connection with the settlement of the available lands in this district. In 1924 there were 219 resident owners who were irrigating 21,912 acres showing a gross return for the year of a little over $354,000. At the close of 1926 there were 646 water users who irrigated 56,395 acres during the season, of which 46,253 were cropped and harvested with a gross value of $1,035,017 or representing an increase over 1924 of $681,000. The gross returns for 1926 show an increase over 1925 of $22,000. The present population on the project has been reported as 3,250 an increase of 100 per cent over the previous year. Over 10,000 acres of new land have been broken and will be in readiness for the 1927 season. There still remain some 30,000 acres of irrigable and non-irrigable land to be settled, a large proportion of which is land on which there is a first mortgage under the Act and for various reasons is not at present available for settlement by the Provincial Colonization Branch.

Engineering assistance was again rendered the district for the laying out of farm laterals—six of the departmental engineers visited some 200 farms, located head ditches or gave advice on methods of irrigation and the most economical use of water. The total acreage surveyed for ditches was 10,326 acres for 174 farmers or an average acreage of 59·3 per farm.

During the year 94,215 acre-feet of water were diverted from the Oldman river, some of which has been stored in Keho Lake reservoir. Water was turned into the system on April 22 and the headgates closed on October 16, the highest daily discharge recorded being 568 cubic-feet per second on June 17.

UNITED IRRIGATION DISTRICT

This district, diverts its water from the Belly river in section 13, township 3, range 28, west of the 4th meridian. There are 36,158 irrigable acres in the district, of which 10,826 were actually irrigated during the season of 1926 as compared with 27,118 in 1925.

Water was turned into the system on April 19, and the headgates closed down on October 31. A total of 24,700 acre-feet of water was diverted from the Belly river during the season and the highest daily discharge recorded was 271 cubic-feet per second on June 9 and 10. The average daily flow for the month of maximum demand was 126 cubic-feet per second during July.

The precipitation as recorded at Glenwood during the growing season was 11·37 inches, made up as follows: May, 0·12; June, 3·16; July, 1·49; August, 2·89; September, 3·71. Spring conditions were not altogether favourable and high winds in April and May caused considerable damage through soil drifting. The heavy precipitation in the early fall caused considerable damage to crops and delay in harvesting. The period free from damaging frost extended from April 22 to September 15, or 145 days.

A considerable increase in the sugar beet area has taken place during the year, some 570 acres having been devoted to this crop.

A colonization board has been formed in the district to co-operate with the Canadian Pacific Railway Company with a view to bringing in desirable settlers from Europe who are familiar with the sugar beet industry. During the year six new families were brought into the district and have rented land with a view to ultimate purchase as soon as they have become accustomed to local conditions.

CROP RETURNS

Appended are tables summarizing the crop returns for the major operating irrigation projects:—

Summary of 1926 Crop Reports by Irrigation Districts

District	Irrigable area	Irrigated area	Cropped area	Total value cropped area	Value per acre cropped area
	acres	acres	acres	$ cts.	$ cts.
Canadian Pacific Railway Western Section..	218,980	19,561	202,361	3,719,207 77	18 38
Canadian Pacific Railway Eastern Section.....	137,310	74,401	71,489	1,526,667 95	21 35
Canadian Pacific Railway Lethbridge Section	77,320	70,603	56,908	1,673,238 67	29 40
Taber Irrigation District......................	16,939	14,383	14,500	376,693 90	25 98
Canada Land and Irrigation District...........	10,603	10,295	10,389	301,393 56	29 01
New West Irrigation District..................	4,501	3,208	3,095	64,337 87	20 78
Lethbridge Northern Irrigation District......	104,438	48,032	46,253·6	1,035,017 35	22 37
United Irrigation District........................	34,562	10,826	22,262	386,725 05	17 37

Summary of 1926 Crops produced in the Irrigation Districts shown in Table "A"

Crop	Acreage	Average yield per acre	Total yield	Average unit values at harvest	Total value	Per acre value
			Bush.	$ cts.	$ cts.	$ cts.
Wheat	290,906	19·70	5,731,096	1 10	6,304,205 60	21 67
Oats	40,752	26·14	1,065,243	0 50	532,621 50	13 07
Barley	15,100	23·30	351,824	0 55	193,503 20	12 81
Rye	201	15·41	3,097	0 80	2,477 60	12 32
Flax	2,367	9·87	23,369	1 90	44,401 10	18 76
Peas	3	22·00	66	3 00	198 00	66 00
			Tons			
Alfalfa	31,091	2·13	66,123	13 00	859,599 00	27 65
			Lb.			
Alfalfa, seed	2,989	16·63	49,707	0 25	100,292 50	33 55
			Tons			
New alfalfa	343	0·38	130	....	1,690 00	4 93
Timothy	7,438	1·05	7,825	18 00	140,850 00	18 94
Timothy and alfalfa	1,619	2·00	3,230	16 00	51,680 00	31 92
Green feed	22,569	1·12	25,296	14 00	354,144 00	15 69
Other hay	6,868	0·94	6,451	15 00	96,765 00	14 09
Sunflowers	171	7·93	1,356	5 00	6,780 00	39 65
Corn (ensilage)	215	5·85	1,257·5	7 00	8,802 50	40 94
			Bush.			
Potatoes	1,579	145·34	229,483	0 69	158,343 27	100 28
			Tons			
Sugar beets	2,108	7·86	16,576	7 00	116,032 00	55 04
Gardens	344	....	....	269 33	92,650 00	269 33
Pasture grasses (mixed)	458	....	....	25 00	11,447 50	25 00
Pasture (corn)	136	....	....	50 00	6,800 00	50 00
Total crop area	427,257	....	....	....	9,083,282 77	....

UNVALUED AREAS

	Acres		Acres
Sunflowers	2	New alfalfa	5,544
Sugar beets	428	Sweet clover	247
Other roots	16	Peas	5
Gardens	693	Millet and rape	13
Pasture	36,354	Areas where crops not reported	6,156

Irrigation Projects not yet in Operation

LITTLE BOW IRRIGATION DISTRICT

This project diverts its water from the Highwood river on the N.E. ¼ of section 1, township 19, range 29, west of the 4th meridian, near the town of High River. During the period from May 1 to September 30 some 8,680 acre-feet of water were diverted from the Highwood river into the Little Bow river. Under arrangement between the district and provincial authorities a small flow of water was also diverted for domestic purposes throughout the year.

No construction work on the individual schemes for the diversion of the water from the stream channel of the Little Bow river has yet been undertaken, the water at present being used for domestic purposes only.

MAGRATH IRRIGATION DISTRICT

This district was erected pursuant to the provisions of the Irrigation Districts Act of Alberta on June 2, 1924. On June 18, 1926, the Board of Trustees entered into an agreement with the Canadian Pacific Railway Company for the supply of water and for the construction of works necessary for serving the

irrigable lands within the district. This agreement was duly approved by the department on July 9, 1926. Under its terms the company agrees to supply at the district's headgates 30 cubic-feet of water per second during the irrigation season. In consideration of this service the board undertakes to pay a total sum of $120,000 by the delivery of debentures to this amount of the par value of $1,000 payable at the Bank of Montreal in the city of Montreal in twenty-eight equal annual instalments with interest at the rate of six per cent. The first instalment of principal sum to be payable on December 1, 1929, and first instalment of interest on December 1, 1927.

It is also provided that the board pay the sum of $3,375 annually for carriage rights, being at the rate of $112.50 per second foot carried and representing approximately 67½ cents per irrigable acre supplied. The agreement further provides that the Company shall build the necessary works and the district representatives agree to pay the actual cost of construction. The estimated cost of the works being $80,000, debentures for this amount were issued by the board after the execution of the agreement and lodged in escrow with the Bank of Montreal at Magrath to be delivered only to the actual amount of the cost of construction as certified by the manager of the Department of Natural Resources of the company. The works constructed, with the exception of the two headgates, are to be maintained and operated by the board, which assumes all the duties and responsibilities of a licensee under the Irrigation Act.

It is also agreed that the Board of Trustees act as agent for the company for the delivery of water to those lands within the district previously held under water agreements and to collect the water rentals due to the company.

The water supplied to this district is diverted from the St. Mary river and carried through the works of the company to the district's headgates.

The irrigation company placed an engineering party in the field on June 23 and proceeded immediately with the location of the main canals and distributaries. Construction work commenced on August 15 and was discontinued on account of bad weather conditions on December 15. At the close of the season it was estimated that 90 per cent of the work had been completed. Some 160,000 cubic yards of earth work were moved during the period, 3 per cent of which, due to loose gravel or solid rock, was classified other than ordinary excavation. There were three concrete structures completed:—

1. Headworks for Magrath lateral.
2. Headworks for main lateral at head of Pothole coulee.
3. Railway culvert on main lateral in SW. ¼ section 21, township 5, range 22, west of 4th meridian.

At the close of the season some 170,000 f.b.m. had been placed in timber structures, leaving some 160,000 f.b.m. to complete this work. The only portion of the completed work which presented any difficulty was in the first mile of the Magrath lateral where a sliding side hill condition necessitated the use of heavy excavating machinery. The works should be completed and in readiness for operation at the opening of the 1927 irrigation season. Under clause 12 of the agreement entered into between the Alberta Railway and Irrigation Company and the trustees of the irrigation district, provision is made for those water users originally served by the irrigation company's Magrath lateral to be taken care of by the newly created district.

RAYMOND IRRIGATION DISTRICT

An agreement between the Alberta Railway and Irrigation Company and the Raymond Irrigation District was entered into on the 12th May, 1926, and duly approved by the department on the 29th May. Under the terms of this

agreement the company will deliver to the district in consideration of $160,000 a quantity of water equivalent to 40 cubic-feet per second during the irrigation season through headgates constructed and maintained by the company at suitable points along its canals. The agreement further provides that the Board of Trustees for the district shall in accordance with the terms of the Irrigation Act maintain, repair, renew and operate all works within the boundaries of the district and assume all obligations imposed upon the company for the maintenance and operation of these works.

In addition to the purchase price for water, the district agrees to pay to the company an annual water rental of $4,500 and undertakes as agent for the company to collect the rental on those lands included in the district which hold water agreements with the company and pay to the company the sum of $112.50 for every second-foot of water covered by such agreements.

No separate records of water supply or crop yields have been made for this district, the figures being included in the general return of the Alberta Railway and Irrigation Company. It is anticipated, however, that this district will submit its own returns for the coming season.

The district receives its water supply from the St. Mary river through the works of the Alberta Railway and Irrigation Company, their headgate being located in the NE. $\frac{1}{4}$ of section 5, township 8, range 21, west of the 4th meridian.

MOUNTAIN VIEW DISTRICT

This district was authorized on June 23, 1925, on condition that before construction was proceeded with, the district would employ an engineer to prepare suitable plans and supervise the design and construction of the important structures. During the year the department loaned one of its engineers to the district for about a month and a considerable amount of work was completed. While suitable designs have been prepared for the important structures, plans have not yet been filed by the district nor has construction been commenced. It is expected that certain works will be carried out during the coming season but owing to the fact that the farmers of the district are attempting to do all of their own work progress is necessarily slow.

Test Plots

ALKALI TEST PLOTS AT MAPLE CREEK, SASKATCHEWAN

These experimental plots were established with a view to ascertaining the effect of irrigation on heavy soils with high alkali content and to ascertain the effect of these particular conditions on various crops. The work has now been carried over a period of five years and it is intended to continue for a further like period. While no definite conclusions have yet been arrived at it is interesting to note that the growth of alfalfa on the plots indicates that it is admirably adapted to this class of soil. A study of all the results of soil tests during the past five years leads to only one definite conclusion which is that the movement of alkali so far has not approached the surface.

METEOROLOGICAL DATA

The two following plates illustrate the average conditions in central Alberta and the semi-arid region of Alberta, respectively. Plate 8 shows that the natural precipitation is normally adequate to ensure average yields. Plate 9, however, again indicates that in a normal year the natural precipitation is insufficient to furnish the moisture required to produce an average crop. Both plates cover a period exceeding 40 years of record.

BROOKS "DUTY OF WATER" EXPERIMENT STATION

CLIMATOLOGY

Weather conditions during the first four months, April to July, were most favourable for crop growth. The rainfall was below average in amount, but in effect was unusually beneficial because of favourable distribution and by practice of irrigation ideal moisture conditions were easily maintained. Moreover high mean temperatures, without extremes, obtained. Hot winds were not prevalent and evaporation losses were relatively low.

Summary Meteorological Data—April-October (inclusive) 1926, Brooks, Alberta

Month	Temperature Data °F.						Precipitation (in inches)		Evaporation (in inches)		Average hourly wind velocity	Average per cent Rel. Humidity 8.00 a.m. 6.00 p.m.
	Maximum recorded	Minimum recorded	Mean maximum	Mean minimum	Mean	Departure of mean from average	Total	Departure from average	Total	Departure from average		
April	85·0	8·0	62·9	30·8	46·8	+4·6	0·19	−0·80	3·05	+0·18	7·0	49
May	84·0	25·0	72·0	41·0	56·0	+4·6	1·23	+0·30	4·03	−1·19	8·3	50
June	95·0	32·0	73·0	45·5	60·3	−0·3	1·53	−0·44	4·58	−0·80	7·0	51
July	95·0	42·0	84·7	52·7	68·6	+1·4	0·59	−0·91	5·55	−0·61	5·5	48
August	91·0	38·0	74·7	46·9	60·6	−3·6	2·06	+0·52	3·61	−1·19	5·0	60
September	72·0	15·5	56·9	34·4	45·7	−8·0	1·52	+0·06	1·66	−1·61	6·3	77
October	78·0	22·0	57·7	31·7	44·4	+4·4	0·09	....	1·36	....	....	69
Seasonal mean	85·7	26·1	68·8	40·4	54·6	....	....	....	....	....	6·5	58
Seasonal total	....	....	....	....	....	+15·0 −11·9	7·21	+0·88 −2·15	23·84	+0·18 −5·40	....	....
Seasonal net deviation	....	....	....	....	....	+3·1	....	−1·27	....	−5·22		

Mean Temperatures, Precipitation and Evaporation with Departures from Averages for the Period—April-October (inclusive) 1926 at representative points throughout the Irrigated Sections of Alberta

—	Month	Strathmore El. 3190		Brooks El. 2461		Vauxhall		Coaldale El. 2828		Macleod		Raymond	Glenwood	Summary	
		Totals means 1926	Departures 1915-24 averages	Totals means 1926	Departures 1915-24 averages	Totals means 1926	Departures 1915-24 averages	Totals means 1926	Departures 1915-24	Totals means 1926	Departures	Totals means 1926	Totals means 1926 *	Average mean and totals	Average net departures
Temperature	April	43·0	+3·8	46·8	+4·6	45·0	+1·0	47·5	+5·6	45·1	+3·1	44·6	....	45·3	+3·6
	May	53·0	+4·3	56·0	+4·6	54·0	+2·1	54·9	+4·6	54·8	+4·8	54·4	54·2	54·5	+4·1
	June	58·3	+2·9	60·3	−0·3	61·0	+0·6	59·0	0·0	59·8	+1·8	58·2	59·4	59·4	+1·0
	July	64·8	+2·4	68·6	+1·4	68·2	+1·5	66·7	+1·5	68·3	+4·3	66·6	65·4	66·9	+2·2
	August	56·9	−2·6	60·6	−3·6	60·2	−4·3	60·4	−3·6	60·8	−1·2	60·0	60·0	59·8	−3·1
	September	41·8	−8·5	45·7	−8·0	43·6	−10·9	45·9	−8·5	44·3	−8·7	43·6	41·2	43·7	−8·9
	October	42·7	+3·7	44·4	+4·4	45·0	+2·0	47·9	+1·9	48·8	+3·8	46·4	46·6	46·0	+3·2
	Averages	51·5	+6·0	54·6	+3·1	53·9	−8·0	54·6	+1·5	54·6	+7·9	53·4	....	53·8	+2·1
Precipitation	April	0·19	−0·94	0·19	−0·80	0·08	−0·87	0·30	−0·82	0·57	−0·09	0·67	0·02	0·29	−0·70
	May	0·36	−1·79	1·23	+0·30	0·84	−0·40	0·94	−0·81	0·12	−1·99	0·57	0·12	0·60	−0·94
	June	3·51	+1·04	1·53	−0·44	1·32	−0·80	4·33	+2·09	4·41	+1·78	4·03	3·16	3·19	+0·73
	July	0·68	−1·63	0·59	−0·91	0·84	−0·85	1·08	−0·97	1·50	+0·41	0·72	1·49	0·99	−0·79
	August	5·34	+3·19	2·06	+0·52	4·00	+2·90	1·66	+0·30	1·98	+0·50	1·18	2·89	2·73	+1·48
	September	3·57	+1·86	1·52	+0·06	1·46	+0·25	4·52	+2·70	4·94	+3·71	2·61	4·41	3·29	+1·72
	October	0·31	−1·36	0·09	......	0·37	−0·37	0·17	−0·54	0·27	−0·18	......	0·50	0·28	−0·61
	Sums	13·83	+0·37	7·21	−1·27	8·91	−0·14	13·00	+1·95	13·79	+4·14	......	12·59	11·55	+0·89
Evaporation	April	3·19	+0·31	3·05	+0·18	......	......	3·32	+0·09	......	......	......	......	......	......
	May	4·86	+0·14	4·03	−1·19	......	......	4·78	−0·14	......	......	......	......	......	......
	June	5·25	+0·57	4·58	−0·80	......	......	7·08	+1·83	......	......	......	......	......	......
	July	5·47	+0·15	5·55	−0·61	......	......	4·87	−1·51	......	......	......	......	......	......
	August	3·87	+0·06	3·61	−1·19	......	......	3·80	−1·55	......	......	......	......	......	......
	September	1·00	−1·66	1·66	−1·61	......	......	1·90	−1·87	......	......	......	......	......	......
	October	1·13	......	1·36	......	......	......	1·72	......	......	......	......	......	......	......
	Sums	24·59	−0·43	23·84	−5·22	......	......	27·47	−3·15	......	......	......	......	......	......

PLATE 8

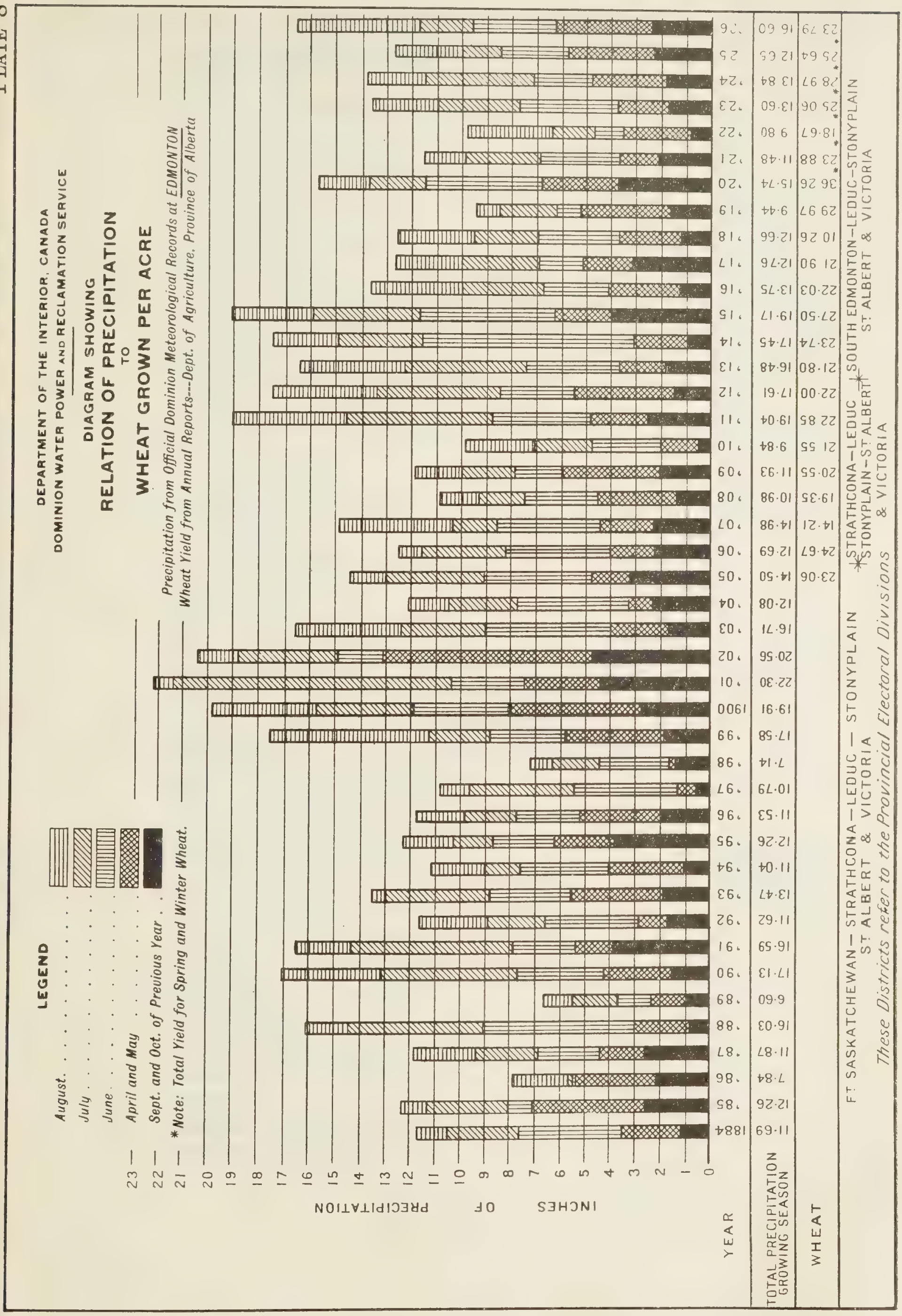
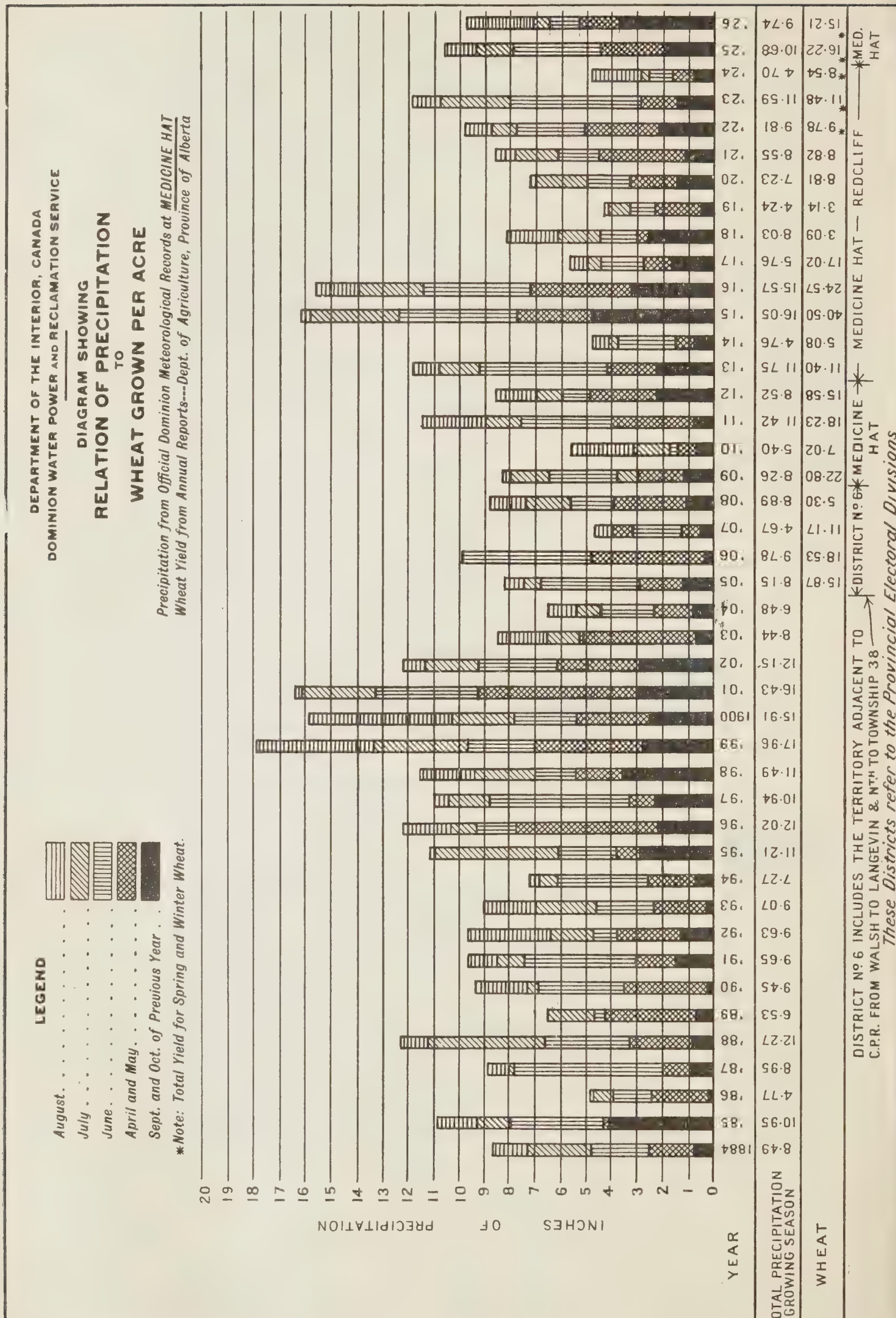

DEPARTMENT OF THE INTERIOR, CANADA
DOMINION WATER POWER AND RECLAMATION SERVICE
DIAGRAM SHOWING
RELATION OF PRECIPITATION
TO
WHEAT GROWN PER ACRE
Precipitation from Official Dominion Meteorological Records at EDMONTON
Wheat Yield from Annual Reports--Dept. of Agriculture, Province of Alberta
LEGEND
August
July
June
April and May
Sept. and Oct. of Previous Year
*Note: Total Yield for Spring and Winter Wheat.
INCHES OF PRECIPITATION
YEAR
TOTAL PRECIPITATION GROWING SEASON
WHEAT
1884 11·69
'85 12·26
'86 7·84
'87 11·87
'88 16·03
'89 6·60
'90 17·13
'91 16·59
'92 11·62
'93 13·47
'94 11·04
'95 12·26
'96 11·53
'97 10·79
'98 7·14
'99 17·58
1900 19·91
'01 22·30
'02 20·56
'03 16·71
'04 12·08
'05 14·50 23·06
'06 12·69 24·67
'07 14·98 14·21
'08 10·98 19·35
'09 11·93 20·55
'10 9·84 21 55
'11 19·04 22 85
'12 17·61 22·00
'13 16·48 21·80
'14 17·45 23·74
'15 19·17 27·50
'16 13·75 22·03
'17 12·76 21 90
'18 12·66 10 26
'19 9·44 29 97
'20 15·74 36 26
'21 11·48 23 88
'22 9 80 18·67*
'23 13·60 25 06*
'24 13 84 28 97*
'25 12 65 25 64*
'26 16 60 23 79*
Ft SASKATCHEWAN—STRATHCONA—LEDUC—STONYPLAIN
St ALBERT & VICTORIA
STRATHCONA—LEDUC
STONYPLAIN—St ALBERT & VICTORIA
SOUTH EDMONTON—LEDUC—STONYPLAIN
St ALBERT & VICTORIA
These Districts refer to the Provincial Electoral Divisions

PLATE 9


DEPARTMENT OF THE INTERIOR, CANADA
DOMINION WATER POWER AND RECLAMATION SERVICE
DIAGRAM SHOWING
RELATION OF PRECIPITATION
TO
WHEAT GROWN PER ACRE
Precipitation from Official Dominion Meteorological Records at MEDICINE HAT
Wheat Yield from Annual Reports---Dept. of Agriculture, Province of Alberta
LEGEND
August
July
June
April and May
Sept. and Oct. of Previous Year
*Note: Total Yield for Spring and Winter Wheat.
INCHES OF PRECIPITATION
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
YEAR
1884 '85 '86 '87 '88 '89 '90 '91 '92 '93 '94 '95 '96 '97 '98 '99 1900 '01 '02 '03 '04 '05 '06 '07 '08 '09 '10 '11 '12 '13 '14 '15 '16 '17 '18 '19 '20 '21 '22 '23 '24 '25 '26
TOTAL PRECIPITATION GROWING SEASON
8·49 10·95 4·77 8·95 12·27 6·53 9·45 9·65 9·63 9·07 7·27 11·21 12·02 10·94 11·49 17·96 15·91 16·43 12·15 8·44 6·48 8·15 9·78 4·67 8·89 8·26 5·40 11·42 8·52 11·75 4·76 16·05 15·57 5·76 8·03 4·24 7·23 8·55 9·81 11·59 4·70 10·68 9·74
WHEAT
15·87 18·53 11·17 5·30 22·80 7·02 18·23 15·58 11·40 5·08 40·50 24·57 17·02 3·09 3·14 8·81 8·82 9·78* 11·48* 8·54* 16·22* 15·21
DISTRICT No 6 MEDICINE HAT
MEDICINE HAT — REDCLIFF
MED. HAT
DISTRICT No 6 INCLUDES THE TERRITORY ADJACENT TO C.P.R. FROM WALSH TO LANGEVIN & Nth TO TOWNSHIP 38
These Districts refer to the Provincial Electoral Divisions

Unfavourable weather during August and September seriously prolonged harvesting and threshing operations. Late maturing crops were also damaged to some extent by extremely low temperatures toward the end of September. Later, however, the weather cleared up and continued warm and dry to the end of October. All crops were safely harvested and threshed.

SEASON'S RESULTS

The results of the past season's work are given in the following table and on the " Plot Series Record Sheets " which are attached to this report.

The water requirements of wheat and oats were determined when grown under three different conditions of soil fertility, barely under two; and sugar beets under seven. The water requirements of alfalfa were determined for stands two, three and four years old.

The average total depths of water used in producing the maximum crop yields during 1926 were:

For alfafla	32	acre inches.	Average yield	8½ tons
" barley	26	"	"	85 bush.
" oats	24	"	"	116 "
" wheat	20	"	"	73 "
" peas	19	"	"	60 "
" sugar beets	18	"	"	17 tons
" corn	16	"	"	16 "
Average	22			

—	Water applied	Precipi-tation	Total water received	Total water used
	ft.	ft.	ft.	ft.
Average for 7 different crops, 1926	1·63	0·46	2·09	1·84
" 9 " 1925	1·53	0·67	2·20	2·12
" 6 " 1924	1·65	0·58	2·23	2·04
" 9 " 1923	1·07	0·74	1·81	1·77
" 10 " 1922	1·40	0·60	2·02	2·02
" 9 " 1921	1·42	0·46	1·88	1·85
" 11 " 1920	1·45	0·41	1·86	1·83
" 7 " 1919	1·32	0·42	1·74	1·71
" 5 " 1918	1·83	0·25	2·08	1·72
Average	......	......	......	......

The average depth used in producing maximum crop yields in 1926, using 7 different crops, was 22 inches, as compared with an average of 22½ inches for the past nine years.

Irrigation

Plot No.		Crop growth	Maximum yield per acre in 1926	No.	Depth per application	Total depth applied	Rainfall April 1 to harvest	Total depth recorded	Total depth used	Preceding crops
			Bush.							
3	E	Peas........	59·6	4	0·33	1·33	0·49	1·82	1·55	Wheat-oats-barley
63B	B	Wheat......	79·8	6	0·33	2·00	0·30	2·30	2·01	Alfalfa 4 yrs.—beets-beets
78E	D	Wheat......	71·7	3	0·33	1·00	0·30	1·30	1·45	Clover-clover
19	E	Wheat......	68·1	5	0·33	1·67	0·30	1·97	1·63	Peas
Average for Wheat.......			73·2	......	....	1·56	0·30	1·86	1·70	
65E	B-1	Oats........	128·3	4	0·50	2·00	0·30	2·30	2·08	Alfalfa-4 years-oats
61A	B	Oats........	109·7	5	0·33	1·67	0·30	1·97	1·65	Alfalfa-2 yrs.-Corn-Oats-Wheat
21	E	Oats........	109·7	6	0·33	2·00	0·30	2·30	2·22	Peas-Wheat
Average for Oats.........			115·9	......	....	1·89	0·30	2·19	1·98	
7677G	D	Barley......	100·9	6	0·33	2·00	0·49	2·49	2·26	Clover-Clover-Wheat
39A	E	Barley......	69·8	3	0·50	1·50	0·49	1·99	2·01	Peas-Wheat-Oats
Average for Barley.......			85·3	......	....	1·75	0·49	2·24	2·13	
46C	A	Beets.......	20·1	3	0·33	1·00	0·58	1·58	1·28	Alfalfa-5 yrs.-Potatoes
66D	B	Beets.......	19·6	4	0·33	1·33	0·58	1·91	1·78	Clover-2 yrs.-Corn
68C	B	Beets.......	17·9	3	0·33	1·00	0·58	1·58	1·56	Clover-Clover
44C	A	Beets.......	18·0	3	0·33	1·00	0·58	1·58	1·34	Alfalfa-5 yrs.-Potatoes-Wheat
48C	A	Beets.......	16·8	3 1 1	0·33 0·42 0·17	1·58	0·58	2·16	1·73	Alfalfa-6 yrs.
42C	A	Beets.......	16·1	3	0·33	1·00	0·58	1·58	1·05	Alfalfa-5 yrs.-Potatoes-Wheat-Flax
83C	C	Beets.......	10·9	3	0·33	1·00	0·58	1·58	1·60	Grass-3 yrs.
Average for beets.........			17·1*	......	....	1·13	0·58	1·71	1·48	
75A	D-1	Corn........	15·6*	5	0·25	1·25	0·57	1·82	1·36	Clover-2 yrs.-Wheat-Barley
			Tons							
55E	A	Alfalfa......	9·45	6	0·33	2·00	0·52	2·52	2·17	
53B	A	Alfalfa......	8·74	5	0·50	2·50	0·52	3·02	2·77	
57B	A	Alfalfa......	7·25	6	0·50	3·00	0·52	3·52	3·05	
Average for Alfalfa.......			8·48	......	....	2·50	0·52	3·02	2·66	

The last column in the above table inserted as an index to the relative soil fertility of the crop series, due to preceding crops.

* Add dry weight of grain and stover.

Irrigation Experiment Station, Brooks, Alberta—Plot Series Record 1926—Peas (Prussian Blue)

ROTATION "E"

Plot No.	Irrigation Date and Depth Applied in Acre-feet per Acre														Duty of Water	Rainfall April First to Harvest	Total Depth Received	Total Depth used in Growing Crop	Yield per acre	Harvested
	May	June					July						August							
		3	15	17	21	26		5	10	17	20		2							
5 A......	......	....	....	....	....	....	....	....	....	....	....	....	....	....	0·00	0·30	0·30	0·27	34·5	Aug. 5
4 A......	......	....	0·33	....	....	....	....	....	....	....	....	....	....	....	0·33	0·40	0·73	0·53	39·6	" 23
5........	......	0·33	....	..	0·34	....	....	....	....	....	....	....	....	....	0·67	0·30	0·97	1·14	32·6	" 5
4........	......	0·33	....	....	0·33	....	....	....	0·34	....	....	....	....	....	1·00	0·40	1·40	0·97	42·7	" 23
3........	......	0·33	....	....	0·33	....	....	....	0·34	....	....	....	0·33	....	1·33	0·49	1·82	1·55	59·6	Sept. 9
2........	......	0·33	....	0·33	....	....	....	0·34	....	0·33	....	....	0·34	....	1·67	0·49	2·16	2·20	43·9	" 9
1........	......	0·33	....	0·33	....	....	....	0·34	0·33	....	0·33	....	0·34	....	2·00	0·49	2·49	2·69	44·2	" 9
3 A......	......	0·50	....	....	....	0·50	....	....	....	....	....	....	....	....	1·00	0·49	1·49	1·87	49·5	" 9
2 A......	......	0·50	....	....	....	0·50	....	....	....	....	0·50	....	....	....	1·50	0·49	1·99	1·64	44·6	" 9
1 A......	......	0·50	....	....	....	0·50	....	....	....	0·50	....	....	0·50	....	2·00	0·49	2·49	2·40	40·7	" 9

Irrigation Experiment Station, Brooks, Alberta—Plot Series Record 1926—Wheat (Marquis)

ROTATION B 62-63

Plot No.	Irrigation Date and Depth Applied in Acre-feet per Acre														Duty of Water	Rainfall April First to Harvest	Total Depth Received	Total Depth used in Growing Crop	Yield per acre	Harvested
	May	June					July						August							
	31		12	17	22	25	2	10	15	21	27									
62 A															0·00	0·30	0·30	0·75	16·5	
62 B			0·33												0·33	0·30	0·63	0·62	19·4	
63 A	0·33				0·34										0·67	0·30	0·97	0·92	72·7	
62 D	0·33				0·33			0·34							1·00	0·30	1·30	1·33	71·0	
62 E	0·33				0·33			0·34			0·34				1·34	0·30	1·64	1·77	66·3	
62 C	0·33			0·33			0·34		0·33		0·34				1·67	0·30	1·97	1·60	74·2	
63 B	0·33			0·33			0·34	0·33		0·33	0·34				2·00	0·30	2·30	2·01	79·8	
63 C	0·50					0·50									1·00	0·30	1·30	1·58	61·1	
63 D	0·50					0·50				0·50					1·50	0·30	1·80	1·90	67·5	
63 E	0·50					0·50			0·50		0·50				2·00	0·30	2·30	2·53	73·1	

ROTATION D 78-79

Plot No.	May	June					July						August							Harvested
	31		15	17	21	26	2	10	15	20	30									
78 A															0·00	0·30	0·30	0·57	13·6	July 27
78 B			0·33												0·33	0·30	0·63	1·02	51·5	" 31
78 C	0·33				0·34										0·67	0·30	0·97	1·35	64·8	Aug. 2
78 D	0·33				0·33			0·34							1·00	0·30	1·30	1·53	63·1	" 2
78 E	0·33				0·33			0·34				0·33*			1·00	0·30	1·30	1·45	71·7	" 2
79 A	0·33			0·33			0·34		0·33			0·33*			1·33	0·30	1·63	1·77	56·4	July 31
79 B	0·33			0·33			0·34	0·33		0·33		0·33*			1·66	0·30	1·96	2·00	56·8	" 31
79 C	0·50					0·50									1·00	0·30	1·30	1·45	64·7	Aug. 2
79 D	0·50					0·50				0·50					1·50	0·30	1·80	1·70	60·9	" 2
79 E	0·50					0·50			0·50			0·50*			1·50	0·30	1·80	1·87	53·4	" 2

* These four irrigations not applied on account of early maturity of crop.

ROTATION E 16-20

Plot No.	May	June					July						August							
		4	15	18	22	26	5	10	12	17	21	29								
16 A															0·00	0·30	0·30	0·61	29·2	
17 A			0·34												0·34	0·30	0·64	0·85	48·2	
16		0·33			0·34										0·67	0·30	0·97	1·07	51·9	
17		0·33			0·33				0·34						1·00	0·30	1·30	1·63	62·6	
18		0·33			0·33				0·34			0·33			1·33	0·30	1·63	1·74	64·0	
19		0·33		0·33			0·34			0·33		0·33			1·67	0·30	1·97	1·63	68·1	
20		0·33		0·33			0·34		0·33		0·33	0·34			2·00	0·30	2·30	2·68	58·8	
18 A		0·50				0·50									1·00	0·30	1·30	1·11	60·6	
19 A		0·50				0·50					0·50				1·50	0·30	1·80	1·95	64·8	
20 A		0·50				0·50				0·50		0·50			2·00	0·30	2·30	2·44	57·0	

Irrigation Experiment Station, Brooks, Alberta—Plot Series Record 1926—Oats (Banner)

ROTATION B 60-61

Plot No.	Irrigation Date and Depth Applied in Acre-feet per Acre														Duty of Water	Rainfall April First to Harvest	Total Depth Received	Total Depth used in Growing Crop	Yield per acre	Remarks
	May	June					July						August							
		2		16	21	28	2	10	16	21			2							
60 A															0·00	0·30	0·30	0·45	21·6	
B		0·33													0·33	0·30	0·63	0·41	62·0	
C		0·33			0·33										0·66	0·30	0·96	0·76	87·7	
D		0·33			0·33			0·34							1·00	0·30	1·30	1·27	87·7	
E		0·33			0·33			0·34					0·33		1·33	0·30	1·63	1·36	104·7	
61 A		0·33		0·33			0·34	0·33	0·33				0·33		1·67	0·30	1·97	1·65	109·7	
B		0·33		0·33			0·34			0·33			0·34		2·00	0·30	2·30	2·03	99·8	
C		0·50				0·50									1·00	0·30	1·30	1·44	92·1	
D		0·50				0·50				0·50					1·50	0·30	1·80	1·83	......	Discarded

ROTATION B-1 64-65

Plot No.	May	June					July						August							Harvested
		1	12	17	21	28	2	10	16	21			3							
64 A															0·00	0·30	0·30	0·33	19·9	July 27
65 A			0·33												0·33	0·30	0·63	0·45	115·2	Aug. 10
64 C		0·33			0·33										0·66	0·30	0·96	1·11	113·5	" 10
64 D		0·33			0·33			0·34							1·00	0·30	1·30	1·18	114·0	" 10
64 E		0·33			0·33			0·34					0·33		1·33	0·30	1·63	1·57	115·5	" 10
64 B		0·33		0·33			0·34		0·33				0·33		1·67	0·30	1·97	1·61	119·9	Aug. 11
65 B		0·33		0·33			0·34	0·33		0·33			0·34		2·00	0·30	2·30	1·92	127·1	" 11
65 C		0·50				0·50									1·00	0·30	1·30	1·35	118·0	Aug. 10
65 D		0·50				0·50				0·50					1·50	0·30	1·80	1·65	115·3	" 10
65 E		0·50				0·50			0·50				0·50		2·00	0·30	2·30	2·08	128·3	" 10

ROTATION E 21-25

Plot No.	May	June					July						August							
		5	15	18	22	28	5	12	19	21			3							
25 A															0·00	0·30	0·30	0·18	54·4	
24 A			0·33												0·33	0·30	0·63	0·66	76·9	
25		0·33			0·34										0·67	0·30	0·97	1·32	74·7	
24		0·33			0·33			0·34							1·00	0·30	1·30	1·29	87·3	
23		0·33			0·33			0·34					0·33		1·33	0·30	1·63	1·25	83·4	
22		0·33		0·33			0·34		0·34				0·33		1·67	0·30	1·97	1·67	100·1	
21		0·33		0·33			0·34	0·34		0·33			0·33		2·00	0·30	2·30	2·22	109·7	
23 A		0·50				0·50									1·00	0·30	1·30	1·42	83·9	
22 A		0·50				0·50				0·50					1·50	0·30	1·80	1·89	104·5	
21 A		0·50				0·50			0·50				0·50		2·00	0·30	2·30	1·98	52·7	

Irrigation Experiment Station, Brooks, Alberta—Plot Series Record 1926—Barley (Banks)

ROTATION D 7677

Plot No.	Irrigation Date and Depth Applied in Acre-feet per Acre — June 12	June 21	June 26	June 30	July 5	July 10	July 20	July	August 3	August 5	Duty of Water	Rainfall April First to Harvest	Total Depth Received	Total Depth used in Growing Crop	Yield per acre	Harvested
7677 A											0·00	0·30	0·30	0·72	8·3	Aug. 11
B		0·33									0·33	0·49	0·82	0·54	62·8	Sept. 7
C	0·33			0·33							0·66	0·49	1·15	0·99	93·5	" 7
D	0·33			0·33			0·34				1·00	0·49	1·49	1·93	92·2	" 7
E	0·33			0·33			0·34			0·33	1·33	0·49	1·82	2·03	93·6	" 7
F	0·33		0·33			0·34	0·33		0·34		1·67	0·49	2·16	1·88	98·2	" 7
G	0·33	0·33		0·34		0·33	0·33		0·34		2·00	0·49	2·49	2·26	100·9	" 7
H	0·50				0·50						1·00	0·49	1·49	1·42	101·3	" 7
J	0·50				0·50				0·50		1·50	0·49	1·99	1·83	81·6	" 7
K																

ROTATION E

Plot No.	June 15	June 22	June	June 29	July 6	July 13	July 19	July 22	August 4	August						
36 A											0·00	0·32	0·32	......	33·7	Aug. 17
37 A		0·33									0·33	0·49	0·82	0·75	35·7	Sept. 9
36	0·33				0·34						0·67	0·49	1·16	......	38·9	" 9
37	0·33				0·33			0·34			1·00	0·49	1·49	......	59·4	" 9
38	0·33				0·33			0·34	0·33		1·33	0·49	1·82	......	65·3	" 9
39	0·33			0·33				0·33	0·34		1·67	0·49	2·16	2·01	67·8	" 9
40	0·33	0·33			0·34			0·33	0·34		2·00	0·49	2·49	2·31	65·2	" 9
38 A	0·50				0·50						1·00	0·49	1·49	1·38	58·4	" 9
39 A	0·50				0·50				0·50		1·50	0·49	1·99	2·01	69·8	" 9
40 A	0·50				0·50		0·50		0·50		2·00	0·49	2·49	2·45	44·3	" 9

Irrigation Experiment Station, Brooks, Alberta—Plot Series Record 1926—Sugar Beets (Kleinwanzleben)

ROTATION A–42

Plot No.	Irrigation Date and Depth Applied in Acre-feet per Acre — June 15	July 12	July	July 16	July 31	August 5	August 16	August 20	August 30	Sept. 11	Duty of Water	Rainfall April First to Harvest	Total Depth Received	Total Depth used in Growing Crop	Yield per acre
42 A	0·33										0·33	0·58	0·91	0·81	10·8
B	0·33				0·34						0·67	0·58	1·25	1·03	14·5
C	0·33			0·33			0·34				1·00	0·58	1·58	1·05	16·1
D	0·33	0·33				0·34			0·33		1·33	0·58	1·91	1·74	14·6
E	0·33	0·33			0·34			0·33		0·34	1·67	0·58	2·25	1·73	12·9

ROTATION A–44

Plot No.	June 16	July 12	July 16	July 31	August 5	August 16	August 20	August 31	Sept. 11					
44 A	0·33									0·33	0·58	0·91	1·03	11·7
B	0·33			0·34						0·67	0·58	1·25	0·71	17·6
C	0·33		0·33			0·34				1·00	0·58	1·58	1·34	18·0
D	0·33	0·33			0·34			0·33		1·33	0·58	1·91	1·45	17·5
E	0·33	0·33		0·34			0·33		0·34	1·67	0·58	2·25	1·91	17·8

Irrigation Experiment Station, Brooks, Alberta—Plot Series Record 1926—Sugar Beets (Kleinwanzleben)—Con.

ROTATION A-46

Plot No.	Irrigation Date and Depth Applied in Acre-feet per Acre									Duty of Water	Rainfall April First to Harvest	Total Depth Received	Total Depth used in Growing Crop	Yield per acre
	June	July			August				Sept.					
	15	10	16	31	5	16	20	31	11					
46 A	0·33	......	......	......	....	....	....	....	......	0·33	0·58	0·91	0·92	16·0
46 B	0·33	......	......	0·34	....	....	....	....	......	0·67	0·58	1·25	1·23	18·9
46 C	0·33	......	0·33	......	....	0·34	....	....	......	1·00	0·58	1·58	1·28	20·1
46 D	0·33	0·33	......	......	0·34	....	....	0·33	......	1·33	0·58	1·91	1·61	19·9
46 E	0·33	0·33	......	0·34	....	....	0·33	....	..0·34	1·67	0·58	2·25	1·98	19·4

ROTATION A-48

Plot No.	June	July			August				Sept.	Duty of Water	Rainfall April First to Harvest	Total Depth Received	Total Depth used in Growing Crop	Yield per acre
	9	3		19	2			23						
48 A	0·33	......	......	......	....	....	....	....	......	0·33	0·58	0·91	1·17	11·8
B	0·33	0·34	......	......	....	....	....	....	......	0·67	0·58	1·25	1·08	13·0
D	0·25	0·33	......	0·33	....	....	....	....	......	0·91	0·58	1·49	1·43	16·1
E	0·33	0·33	......	0·33	0·33	....	....	....	......	1·32	0·58	1·90	1·61	*16·0
C	0·17	0·33	......	0·33	0·33	....	....	0·42	......	1·58	0·58	2·16	1·73	16·8

*Estimated.

ROTATION C-66

Plot No.	June	July		August					Sept.	Duty of Water	Rainfall April First to Harvest	Total Depth Received	Total Depth used in Growing Crop	Yield per acre
	15	12	14	2	5	16	20	31	11					
66 A	0·33	......	......	....	....	....	....	....	......	0·33	0·58	0·91	0·86	13·5
B	0·33	......	......	0·34	....	....	....	....	......	0·67	0·58	1·25	1·12	16·4
C	0·33	......	0·33	....	....	0·34	....	....	......	1·00	0·58	1·58	1·60	19·4
D	0·33	0·33	......	....	0·34	....	....	0·33	......	1·33	0·58	1·91	1·78	19·6
E	0·33	0·33	......	0·34	....	....	0·33	....	0·34	1·67	0·58	2·25	1·94	17·2

ROTATION C-68

Plot No.	June	July			August					Sept.	Duty of Water	Rainfall April First to Harvest	Total Depth Received	Total Depth used in Growing Crop	Yield per acre
	15	10	12	14	2	5	16	20	31	11					
68 A	0·33	....	....	....	....	....	....	....	....	......	0·33	0·58	0·91	1·23	12·4
B	0·33	....	....	....	0·34	....	....	....	....	......	0·67	0·58	1·25	0·90	15·4
C	0·33	....	....	0·33	....	....	0·34	....	....	......	1·00	0·58	1·58	1·56	17·9
D	0·33	0·33	....	....	....	0·34	....	....	0·33	......	1·33	0·58	1·91	1·47	15·1
E	0·33	....	0·33	....	0·34	....	....	0·33	....	0·34	1·67	0·58	2·25	1·88	13·7

ROTATION C-83

Plot No.	June	July			August					Sept.	Duty of Water	Rainfall April First to Harvest	Total Depth Received	Total Depth used in Growing Crop	Yield per acre
	15	10		15	30	5	16	20	31	11					
83 A	0·33	....	....	....	....	....	....	....	....	......	0·33	0·58	0·91	1·03	7·3
B	0·33	....	....	....	0·34	....	....	....	....	......	0·67	0·58	1·25	1·09	8·3
C	0·33	....	....	0·33	....	....	0·34	....	....	......	1·00	0·58	1·58	1·60	10·9
D	0·33	0·33	....	....	....	0·34	....	....	0·33	......	1·33	0·58	1·91	1·81	8·9
E	0·33	0·33	....	....	0·34	....	....	0·33	....	0·34	1·67	0·58	2·25	1·92	9·9

Irrigation Experiment Station, Brooks, Alberta—Plot Series Record 1926—Corn (Minnesota No. 13)

ROTATION D-1 74-75

Plot No.	Irrigation Date and Depth Applied in Acre-feet per Acre												Duty of Water	Rainfall April First to Harvest	Total Depth Received	Total Depth used in Growing Crop	Yield per acre	Remarks
	June		July					August										
	5	30	7	10	16	20	28	3	5	9	17	23						
74 A	....	....	....	....	....	....	....	....	....	....	....	....	0·00	0·57	0·57	......	6·9	
74 B	0·25	....	....	....	....	....	....	....	....	....	....	....	0·25	0·57	0·82	0·69	12·0	
74 C	0·25	....	....	....	0·25	....	....	....	....	....	....	....	0·50	0·57	1·07	1·10	13·0	
74 D	0·25	....	....	0·25	....	....	....	....	0·25	....	....	....	0·75	0·57	1·32	0·79	13·3	
74 E	0·25	....	0·25	....	....	....	0·25	....	....	0·25	....	....	1·00	0·57	1·57	1·15	11·9	Accident-
75 A	0·25	....	0·25	....	....	0·25	....	....	0·25	....	0·25	....	1·25	0·57	1·82	1·36	15·6	ally
75 B	0·25	0·25	....	....	0·25	....	....	0·25	....	0·25	....	0·25	1·50	0·57	2·07	1·62	13·6	flooded.
75 C	0·37	....	....	....	0·38	....	....	....	....	....	....	....	0·75	0·57	1·32	0·62	11·9	
75 D	0·37	....	....	0·38	....	....	....	0·37	....	....	....	....	1·12	0·57	1·69	1·58	12·9	
75 E	0·37	....	....	0·38	....	....	....	0·37	....	....	0·38	....	1·50	0·57	2·07	1·53	13·0	

Irrigation Experiment Station, Brooks, Alberta—Plot Series Record 1926—Alfalfa (Grimm)

ROTATION A—52-53. SEEDED 1923—4 YEARS OLD

Plot No.	Irrigation Date and Depth Applied in Acre-feet per Acre													Duty of Water	Rainfall April First to Harvest	Total Depth Received	Total Depth used in Growing Crop	Yield per acre	Remarks
	May		June				July						Aug.						
	19	28	6	17	21	28	5	10	12	15	27		9						
52 A	....	....	....	....	....	....	....	....	....	....	....	....	......	0·00	0·52	0·52	0·40	1·67	
52 B	....	....	....	0·50	....	....	....	....	....	....	....	....	......	0·50	0·52	1·02	0·85	2·10	
52 C	....	....	0·50	....	....	....	0·50	....	....	....	....	....	......	1·00	0·52	1·52	1·38	4·40	
52 D	....	0·50	....	....	0·50	....	....	....	....	0·50	....	....	......	1·50	0·52	2·02	......	......	Discarded.
53 A	0·50	....	....	0·50	....	....	0·50	....	....	....	0·50	....	......	2·00	0·52	2·52	2·33	7·40	
53 B	0·50	....	....	0·50	....	0·50	....	0·50	....	....	0·50	....	......	2·50	0·52	3·02	2·77	8·74	
53 C	0·50	....	....	0·50	....	0·50	....	....	0·50	....	0·50	....	0·50	3·00	0·52	3·52	3·22	8·70	
53 E	....	....	....	....	....	....	....	....	....	....	....	....	......	......	......	......	......	......	
52 E	....	....	....	....	....	....	....	....	....	....	....	....	......	......	......	......	......	......	....

ROTATION A 54-55. SEEDED 1924—3 YEARS OLD

Plot No.	May		June				July						Aug.						
	17	27	7	17	21	30	2	5	10	14	27	28	10						
54 A	....	....	....	....	....	....	....	....	....	....	....	....	......	0·00	0·52	0·52	0·72	4·39	
B	....	....	....	0·50	....	....	....	....	....	....	....	....	......	0·50	0·52	1·02	1·12	6·54	
C	....	....	0·50	....	....	....	....	0·50	....	....	....	....	......	1·00	0·52	1·52	1·97	7·15	
D	....	0·50	....	....	0·50	....	....	....	....	0·50	....	....	......	1·50	0·52	2·02	2·13	7·29	
E	0·50	....	....	0·50	....	....	0·50	....	....	....	0·50	....	......	2·00	0·52	2·52	2·47	6·19	
55 A	0·50	....	....	0·50	....	0·50	....	....	0·50	....	....	0·50	......	2·50	0·52	3·02	2·82	8·18	
B	0·50	....	....	0·50	....	0·50	....	....	0·50	....	....	0·50	0·50	3·00	0·52	3·52	3·15	8·68	
C	0·33	....	....	0·33	....	....	....	....	....	....	0·33	....	......	1·33	0·52	1·85	1·66	8·09	
D	0·33	....	....	0·33	....	0·34	....	....	0·33	....	....	0·34	......	1·67	0·52	2·19	1·64	8·07	
E	0·33	....	....	0·33	....	0·34	....	....	0·33			0·34	0·34	2·00	0·52	2·52	2·17	9·45	

ROTATION A 56-57. SEEDED 1925—2 YEARS OLD

Plot No.	May		June				July						Aug.						
	17	27	7	17	21	29	2	5	9	14	27		10						
56 A	....	....	....	....	....	....	....	....	....	....	....	....	......	0·00	0·52	0·52	0·42	1·42	
B	....	....	....	0·50	....	....	....	....	....	....	....	....	......	0·50	0·52	1·02	0·77	3·10	
C	....	....	0·50	....	....	....	....	0·50	....	....	....	....	......	1·00	0·52	1·52	1·80	5·52	
D	....	0·50	....	....	0·50	....	....	....	....	0·50	....	....	......	1·50	0·52	2·02	1·76	5·22	
E	0·50	....	....	0·50	....	....	0·50	....	....	....	0·50	....	......	2·00	0·52	2·52	2·20	5·62	
57 A	0·50	....	....	0·50	....	0·50	....	....	0·50	....	0·50	....	......	2·50	0·52	3·02	2·82	5·56	
B	0·50	....	....	0·50	....	0·50	....	....	0·50	....	0·50	....	0·50	3·00	0·52	3·52	3·05	7·25	
C	0·33	....	....	0·33	....	....	0·34	....	....	....	0·33	....	......	1·33	0·52	1·85	1·72	6·09	
D	0·33	....	....	0·33	....	0·34	....	....	0·33	....	0·33	....	......	1·66	0·52	2·18	1·96	5·34	
E	0·33	....	....	0·33	....	0·34	....	....	0·33	....	0·33	....	0·34	2·00	0·52	2·52	2·25	6·70	

FARM DEMONSTRATION AND EXTENSION WORK

Extension work among the new settlers of the Lethbridge Northern Irrigation District was cárried on during the past season in co-operation with the provincial Department of Agriculture and on much the same lines as during 1925. Engineers from the federal Department of the Interior were assigned certain districts wherein they were to survey laterals sufficient to enable each new settler to irrigate at least 40 acres of each quarter section farmed by him. Additional laterals were to be surveyed where the farmer had made good use of the first survey and the engineer's other duties permitted.

During the first two weeks of May the demand for ditches was very light as most of the farmers had not finished seeding. By the end of May the demand had increased until practically everyone not already served with ditch surveys wished them made at once. No rainfall was received in the Monarch district during this month and while most fields contained sufficient moisture for germination at the beginning of the month it was extracted from the surface soil by steady high winds so that by May 31 the land was so dry that fields seeded during the last two weeks of the month had to be irrigated up. Fields seeded during the first two weeks showed grain 6 inches to 8 inches high.

The first half of June was very dry and crops did not germinate evenly and were beginning to burn when the first light rain fell on the 13th. At this time nearly everyone was irrigating, canals running bank full and farmers working long hours and using large heads of water to provide crops with moisture before they were damaged by the drought. The rain of the 13th served but to germinate such seed as remained in the first two inches of soil as it did not penetrate beyond that depth. Between 6 p.m. June 19 and midnight, June 20, between 4 and 5 inches of rain fell in this district and irrigation was discontinued.

During May and June the six engineers of this Department surveyed laterals covering a total area of 10,326 acres, apportioned among 174 farmers, an average of 59·3 acres per farmer.

During July inspection visits were made to as many farms as possible for the purpose of checking up the conditions of the crops and soil moisture and advising the farmers regarding the application of additional irrigations.

The management of the irrigation project states that a large portion of the success that the project has had this year is due entirely to the great assistance rendered by this department in supplying expert advice and engineering assistance to the farmers.

During the season lectures were delivered on irrigation practice as follows:

June 18.	Rose Butte school Lethbridge Northern project	Attendance	50
" 24.	Picture Butte school Lethbridge Northern project	"	20
July 8.	Iron Springs school Lethbridge Northern project	"	30
" 10.	At Vauxhall for Canada Land and Irrigation Company	"	20
" 14.	At Glenwoodville, United project	"	50
" 17.	At Hillspring, United project	"	30
" 26.	At Medicine Hat Rotary Club	"	100

Irrigation district officials reported noticeable improvement in irrigation practice following these lectures.

CO-OPERATIVE WORK

Quality of Wheat Investigations.—The co-operative work devoted to the study of the kernel quality of wheat in relation to irrigation was continued with the University of Alberta in 1926. Three years' data have now been obtained, and when finally analyzed these will show some very valuable practical results.

Irrigation exerts a marked influence on the quality of wheat which as well as yield must be considered in determining the value of any system of irrigation.

Commenting on the results of the investigation to date, Dr. R. Newton of the University of Alberta states:—

1. "That the protein and baking quality of wheat tends to vary inversely with the quantity of irrigation water applied and the yield per acre."
2. "That this variation may be obviated, to considerabe extent at least, by use of suitable rotations, including leguminous crops."

All chemical, milling, and baking tests in connection with the investigation are being conducted by the University under the direction of Dr. R. Newton. A report of the work when completed will be published by that institution. All field work in connection with the samples produced at Brooks, is being carried on by this department. Brooks is one of several places where the University of Alberta is carrying out co-operative work in connection with quality of wheat investigations.

PROGRESS OF SUGAR BEET INDUSTRY IN ALBERTA

The Sugar Factory at Raymond erected in 1925 is modern in every respect and has a capacity of 1,000 tons of beets per 24 hours. In 1925 the factory manufactured 3,500 tons of sugar from 41,500 tons of beets grown on 5,400 acres. The yield varied from 4 to 20 tons and averaged 7·7 tons per acre. The average percentage of sugar in the beet was 14·41. The 1926 beet tonnage was not up to expectations, being but 35,600 tons. The percentage of sugar was better (16·49) which resulted in the production of 4,800 tons of sugar. The 1926 acreage was 5,100 and the yield per acre 7·3 tons.

The guarantee rate of $5·75 per ton for 1925 beets was increased to $6·25 per ton for 1926 beets and a still further increase of $7 per ton is assured for the 1927 crop.

WATER RFQUIREMENTS OF SUGAR BEETS

During the growing season of 1926, the "Duty of Water" Experiment Station, at Brooks, Alta., had seven different crop-series upon which irrigation investigations were conducted to determine the influence of moisture and soil fertility upon the production of sugar beets. The moisture available to the growing crop varied from one 4-inch irrigation to five 4-inch irrigations, plus the rainfall between seeding and harvest. The soil fertility ranged from excellent after legumes to only fair after non-legume crops.

Each plot was approximately one-thirtieth acre in area. Water was applied by irrigation, measured through 90° "V" notch weirs, and retained on the plots by earth borders. On series 48, the soil moisture content, to a depth of six feet, was determined every four to six days. On the six other crop-series the soil moisture content was determined at the time of seeding and harvest only.

Sugar beet production is a comparatively new industry in the province of Alberta and most farmers engaged in growing this crop are not so well advised as they should be regarding the seasonable water requirements of this plant and the correct methods of supplying this requirement by irrigation to the crop when grown on soils of different texture and fertility.

The irrigation investigations as carried out provide authentic data on the water requirements of the sugar beet crop when grown under soil and climatic conditions comparable to those obtaining in this district.

Preceding Crops.—The following table shows the crops grown on each series for six years prior to 1926:—

Series	1920	1921	1922	1923	1924	1925	1926	Maximum yield 1926 per acre
								tons
48	Flax	Alfalfa	Alfalfa	Alfalfa	Alfalfa	Alfalfa	Beets	16·8
46	Alfalfa	"	"	"	"	Potatoes	"	20·1
44	"	"	"	"	Potatoes	Wheat	"	18·0
42	"	"	"	Potatoes	Wheat	Flax	"	16·1
68	Oats	Wheat	Oats	R. clover	R. clover	R. clover	"	17·9
66	Wheat	Oats	R. clover	"	"	Corn	"	19·6
83	Potatoes	Barley	Wheat	Grass	Grass	Grass	"	10·9

Plate 10. Influence of Irrigation on Yield of Sugar Beets

Graph 1 of plate 10 shows the yields of beets obtained in comparison with the water received and used on seven different crop-series during the season of 1926.

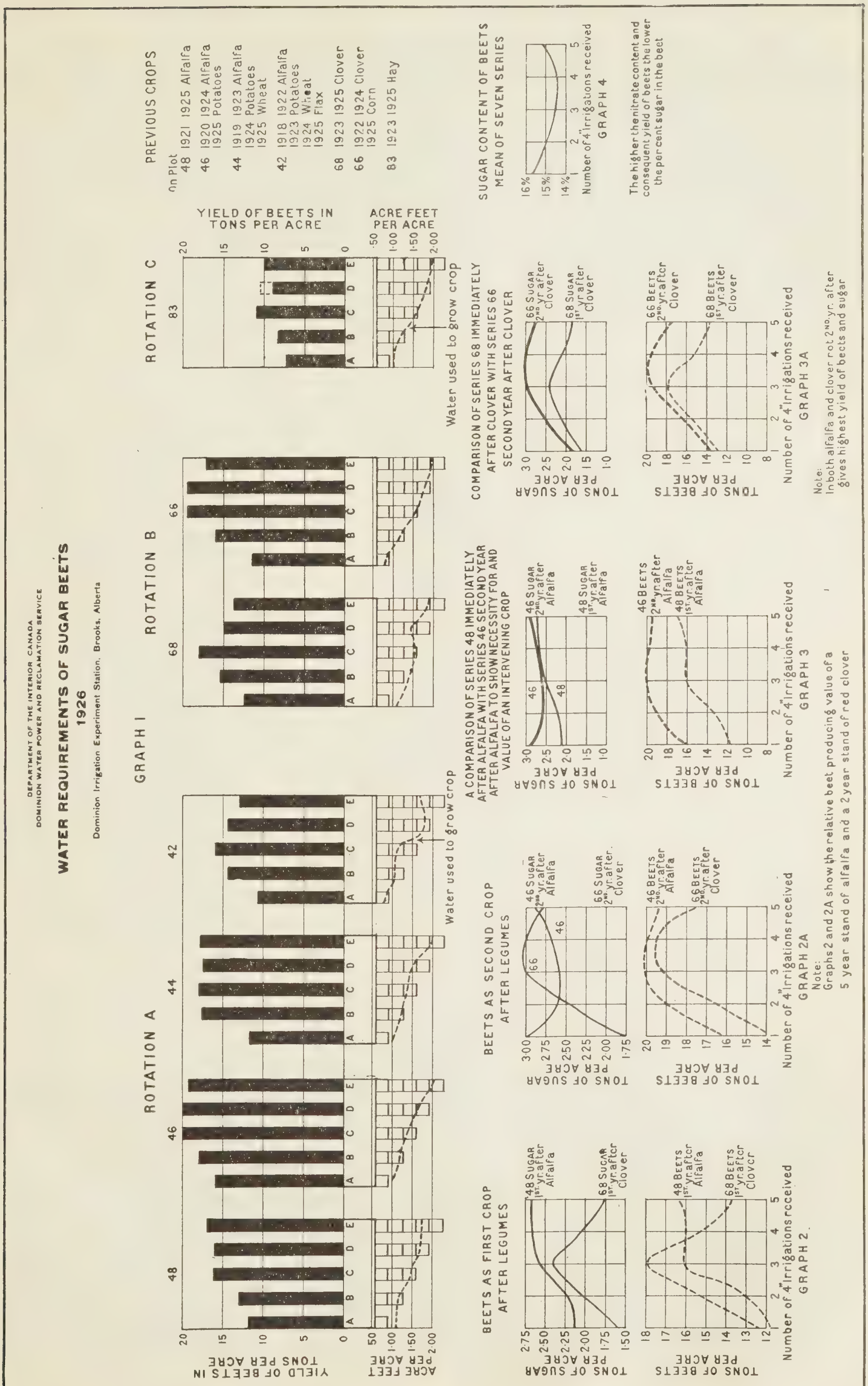
Rotation A.—For series 46, 44 and 42, the maximum yield in each series was produced where *three 4-inch irrigations* (1·00 ft.) were received by the crops in addition to the rain, (0·58 foot). Where either more or less than 3 irrigations were applied the yield was less than the maximum. For series 48 the maximum yield was obtained with 5 irrigations (48c.) but the increase in yield over that obtained with 3 irrigations (48d.) is but 0·7 ton at a cost of two 4-inch irrigations, therefore three irrigations may be considered to have been the most economical for this series.

Rotations B and C.—For series 68, 66 and 83, the maximum yield in each series was produced where *three 4-inch irrigations* (1·00 ft.) were received by the crop in addition to the rainfall between seeding and harvest (0·58) ft.) where either more or less than this amount of water was applied the yield was less than the maximum. The following table gives the amount of water received and used in producing the maximum yield of beets in each crop-series. The term "Water Used" represents the amount of water extracted or lost from the soil to a depth of six feet by percolation, evaporation and transpiration and is indicative of the amount of water actually required to grow the crop when these unavoidable soil water losses are taken into consideration. This is ascertained by adding to the water content of the soil at the time of seeding those amounts of water received as irrigation and rainfall and from this sum deducting the amount of water remaining in the 6-foot soil zone at the time of harvest.

Water Received and Used for Maximum Yields of Beets 1926

Series	Plot	Irrigation	Rainfall	Total water received	Water used	Yield per acre
		" "	"	"		tons
48	D	3x4=12	7	19	17·2	16·1
46	C	3x4=12	7	19	15·4	20·1
44	C	3x4=12	7	19	16·1	18·0
42	C	3x4=12	7	19	12·6	16·1
68	C	3x4=12	7	19	18·7	17·9
66	C	3x4=12	7	19	19·2	19·6
83	C	3x4=12	7	19	19·2	10·9

PLATE 10


DEPARTMENT OF THE INTERIOR CANADA
DOMINION WATER POWER AND RECLAMATION SERVICE
WATER REQUIREMENTS OF SUGAR BEETS
1926
Dominion Irrigation Experiment Station, Brooks, Alberta
GRAPH I
ROTATION A
ROTATION B
ROTATION C
YIELD OF BEETS IN TONS PER ACRE
ACRE FEET PER ACRE
Water used to grow crop
PREVIOUS CROPS
On Plot
48 1921 1925 Alfalfa
46 1920 1924 Alfalfa 1925 Potatoes
44 1919 1923 Alfalfa 1924 Potatoes 1925 Wheat
42 1918 1922 Alfalfa 1923 Potatoes 1924 Wheat 1925 Flax
68 1923 1925 Clover
66 1922 1924 Clover 1925 Corn
83 1923 1925 Hay
BEETS AS FIRST CROP AFTER LEGUMES
GRAPH 2.
BEETS AS SECOND CROP AFTER LEGUMES
GRAPH 2A
A COMPARISON OF SERIES 48 IMMEDIATELY AFTER ALFALFA WITH SERIES 46 SECOND YEAR AFTER ALFALFA TO SHOW NECESSITY FOR AND VALUE OF AN INTERVENING CROP
GRAPH 3
COMPARISON OF SERIES 68 IMMEDIATELY AFTER CLOVER WITH SERIES 66 SECOND YEAR AFTER CLOVER
GRAPH 3A
SUGAR CONTENT OF BEETS MEAN OF SEVEN SERIES
GRAPH 4
TONS OF SUGAR PER ACRE
TONS OF BEETS PER ACRE
Number of 4" Irrigations received
Note: Graphs 2 and 2A show the relative beet producing value of a 5 year stand of alfalfa and a 2 year stand of red clover
Note: In both alfalfa and clover rot 2ND yr. after gives highest yield of beets and sugar
The higher the nitrate content and consequent yield of beets the lower the per cent sugar in the beet

INFLUENCE OF SOIL FERTILITY ON YIELD OF SUGAR BEETS, 1926

1. *Beets as First Crop After Legumes.*—Graph 2 of plate 10 shows the yield of beets and sugar per acre as influenced by the number of 4-inch irrigations received for series 48 where beets follow immediately (or 1st year) after alfalfa in comparison with series 68 where beets follow immediately after red clover. Experiments have indicated that the organic matter, roots, leaves and stems, left in the soil when red clover is ploughed under is more readily converted into available plant food by soil bacteria than is that left when alfalfa is ploughed under. This is because the roots and stems of clover are of a finer texture than those of alfalfa. It is also a fact that a high nitrogen content in the soil, which is brought about by the maintenance of optimum moisture conditions and which produces a maximum yield of beets per acre, favours a low percentage of sugar in the beets, and a low nitrogen content produces low beet yields but a high per cent of sugar. Graph 4, calculated from the mean sugar content of the seven crop series, illustrates this fact. The per cent of sugar being lowest with 3 or 4 irrigations and highest with one and five irrigations.

Three irrigations produced a per acre yield of approximately 18 tons of beets after clover and but 16 tons of beets after alfalfa, due to the more easily converted clover residue. Three irrigations produced 2·55 tons of sugar per acre after alfalfa and but 2·40 tons of sugar per acre after clover, because of the much higher per cent sugar in the alfalfa soil beets. First year after alfalfa produced most sugar per acre; first year after clover produced the most beets per acre with a given irrigation treatment.

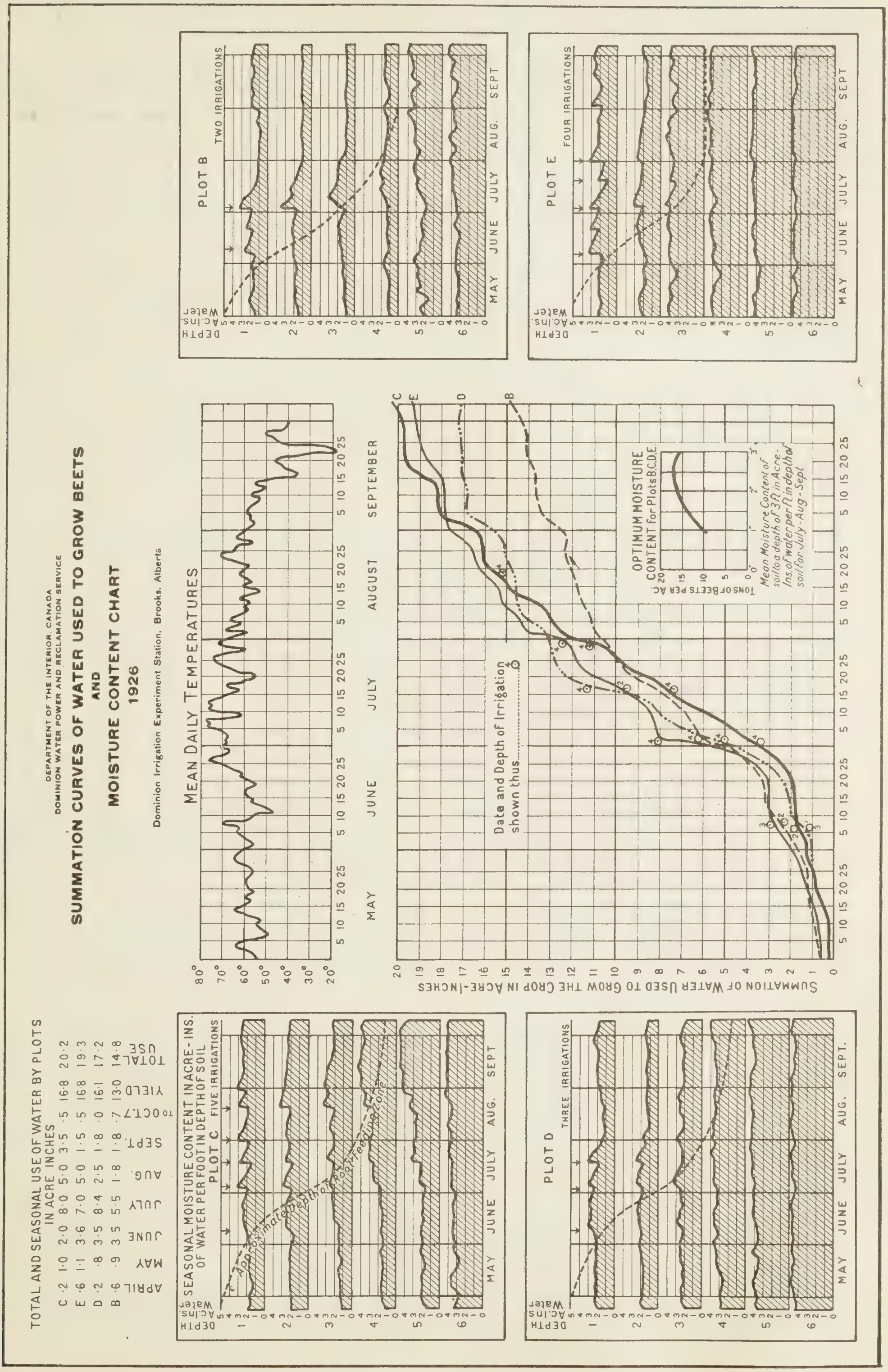
2. *Beets as Second Crop after Legumes.*—Graph 2A shows the yield of beets and sugar per acre as influenced by the number of 4-inch irrigations received for series 46 where beets follow second year after alfalfa in comparison with series 66 where beets follow second year after red clover. Three irrigations produced 20 tons of beets second year after alfalfa and but 19 tons second year after clover. The cultivation and moisture applied to the preceding crop (corn before 66, potatoes before 46) have made possible the elaboration of the plant food locked up in the alfalfa and clover residue so that now the alfalfa soil fertility has apparently increased to a higher beet producing power than the clover, but again with 3 irrigations the per cent sugar in the beet is so much higher after the clover (66) than it is after alfalfa (46) that plot 66C produced 0·4 ton more sugar per acre than plot 46C. These two graphs 2 and 2A, show that three irrigations, or a total amount of water received of 19 inches, has produced per acre as follows:—

After alfalfa	1st year sugar 2·55, 2nd year sugar..	2·60 =	5·15
	2nd year beets 16·00, 2nd year beets..	20·00 =	36·00
After clover	1st year sugar 2·40, 2nd year sugar..	3·00 =	5·40
	2nd year beets 18·00, 2nd year beets..	19·60 =	37·60

The fertility built up by a three-year stand of red clover produced slightly more beets and sugar in the next two years following than did that furnished by a five-year stand of alfalfa.

The Value of an Intervening Cultivated Crop.—Graph 3 gives a comparison of series 48, first year after alfalfa with series 46, second year after alfalfa, to show the value of an intervening crop of potatoes between the alfalfa and the sugar beets. Three 4-inch irrigations, plus rainfall, produce 2 tons more beets and 0·05 ton more sugar per acre for the second crop after alfalfa than for the first. Graph 3A comparing series 68, first year after clover, with series 66, second year after clover, shows that three 4-inch irrigations, plus rainfall, produced 0·8 ton more beets and 0·55 ton more sugar

PLATE 11


DEPARTMENT OF THE INTERIOR, CANADA
DOMINION WATER POWER AND RECLAMATION SERVICE
SUMMATION CURVES OF WATER USED TO GROW BEETS
AND
MOISTURE CONTENT CHART
1926
Dominion Irrigation Experiment Station, Brooks, Alberta
TOTAL AND SEASONAL USE OF WATER BY PLOTS IN ACRE INCHES
APRIL MAY JUNE JULY AUG. SEPT. to OCT.7 YIELD TOTAL USE
C ·2 1·0 2·0 8·0 5·0 3·5 ·5 16·8 20·2
E ·6 1·1 3·6 7·0 5·0 1·5 ·5 16·8 19·3
D ·2 ·8 3·5 8·4 2·5 1·8 ·0 16·1 17·2
B ·6 ·9 3·5 5·5 1·8 1·8 ·7 13·0 14·8
MEAN DAILY TEMPERATURES
SUMMATION OF WATER USED TO GROW THE CROP IN ACRE-INCHES
Date and Depth of Irrigation shown thus
OPTIMUM MOISTURE CONTENT for Plots B,C,D,E
TONS OF BEETS PER AC.
Mean Moisture Content of soil to a depth of 3 ft. in Acre-Ins. of water per ft. in depth of soil for July-Aug.-Sept.
MAY JUNE JULY AUGUST SEPTEMBER
SEASONAL MOISTURE CONTENT IN ACRE-INS. OF WATER PER FOOT IN DEPTH OF SOIL
PLOT C FIVE IRRIGATIONS
Approximate Depth of Root Feeding Zone
PLOT D THREE IRRIGATIONS
PLOT B TWO IRRIGATIONS
PLOT E FOUR IRRIGATIONS
DEPTH Ac.Ins. Water
MAY JUNE JULY AUG. SEPT.

per acre for the second crop after clover than for the first. In both alfalfa and clover series, the second year after produced higher yields of both beets and sugar than did the first.

The results shown on plate 10 were obtained under very favourable conditions and, while quite consistent and reliable in themselves, represent however the results of but one season's work, 1926; therefore, in drawing conclusions from the data presented, due consideration must be given to this fact.

The Seasonal Water Requirements of Sugar Beets.—1. The amount of water that a sugar beet plant will transpire at any stage of growth will depend upon: (*a*) the amount of *water* held in the soil zone occupied by its roots; (*b*) the amount of *energy* as light and heat received from the sun; (*c*) the relative *humidity* of the atmosphere as influenced by wind, rain, surface evaporation and shade; (*d*) the area of its leaf and moisture absorbing root surface; and (*e*) the fertility of the soil or concentration of available soil solution nutrients.

2. The amount of water that is lost to the beet plant by percolation below the soil zone occupied by its roots will depend upon: (*a*) the texture of the soil, whether coarse and of low water retaining capacity as of sand, or fine and of high water retaining capacity as of clay; (*b*) the amount of water held in the root zone at the beginning of the season; and (*c*) the depth applied and frequency of irrigations.

3. The amount of water that is lost to the beet plant by evaporation from the soil's surface is influenced by cultivation and shade of plants, temperature, humidity, sun's energy and amount of water in the soil.

When water is introduced into any soil for the purpose of growing a crop, whether as rainfall or as irrigation, it is extracted or lost from the plant's root zone by the three agencies above described. This combined loss represents the losses that of necessity occur in field practice and indicates that amount of water required to produce or grow the crop. These losses are herein referred to as "*Water Used to Grow the Crop.*"

Many of the forces that influence the amount of water used in growing a crop are not within our control, such as temperature, humidity, light general soil texture and to a great extent leaf surface. We are, however, able to control the losses caused by the variation of the moisture content of the soil by correct irrigation practice, the losses influenced by varying soil fertility by the use of the proper systems of crop rotations and the losses due to evaporation and extent of leaf surface by reasonable farming operations.

Plate 11 shows the seasonable use of water by sugar beets on plot "C" wherein the soil moisture content was maintained at the optimum during the period of growth and, for purpose of comparison, the use of three other plots B, D and E, where the moisture content throughout the season was not so favourable for growth.

Optimum Soil Moisture Content.—Investigations carried out on this soil (fine silt-loam) in 1923 showed that the optimum soil moisture content for wheat was attained when the soil of the root zone contained $2\frac{1}{2}$ acre-inches of water per foot in depth of soil. The small diagram shown to the left of the moisture chart of plot E shows the yield in tons of beets per acre in comparison with a maintained moisture content through July, August and September, of 1, 2 and 3 acre-inches per foot in depth of soil. The maximum yield of beets per acre, 17 tons, was obtained where the moisture content through this period, and to a depth of three feet, was maintained at $2\frac{1}{2}$ inches. This optimum condition prevailed on plot C, which gave a higher tonnage of beets per acre than did B, maintained through the above period (to same depth as C) at 1·4 inches, D maintained at 1·8 inches; or E maintained at $2\frac{1}{2}$ inches, same as C, but having

a less even distribution. A study of the moisture charts through the period of greatest growth, and to a depth from which the roots were drawing their main water supply, supplemented by the yields of beets obtained, indicates that the *optimum moisture content for sugar beets on this soil type is $2\frac{1}{2}$ inches of water per foot in depth of soil.*

Seasonal Use of Water.—The summation-use curves for plots 48B, 48C, 48D and 48E show, by periods, and through different stages of growth, the amounts of water used to bring the beets on these plots to maturity. The data are summarized as follows:

Plot No.	Seasonal use (inches)							Yield of beets in tons per acre	Total depth of water used
	April	May	June	July	Aug.	Sept.	Oct.		
C	0·2	1·0	2·0	8·0	5·0	3·5	0·5	16·8	20·2
E	0·6	1·1	3·6	7·0	5·0	1·5	0·5	....	19·3
D	0·2	0·8	3·5	8·4	2·5	1·8	0·0	16·1	17·2
B	0·6	0·9	3·5	5·5	1·8	1·8	0·7	13·0	14·8
Average	0·4	1·0	3·2	7·2	3·6	2·2	0·4	....	17·9

Principal Factors Affecting Use.—As previously mentioned, the principal variable factors affecting the seasonal use of water on a soil of definite texture and fertility are (*a*) the sun's energy, light, temperature, (*b*) the extent of the leaf and root area of the plant, and (*c*) the amount of water in the root zone.

Influence of Energy on Use.—Considering first the influence of the sun's energy on the rate of growth, we would assume that each of the four plots received the same amount, but after a certain date this would not be true as it is only in the green leaves of the plant that this energy can be assimilated and the amount of it assimilated depends upon the extent of the leaf surface of the plant. Up to the end of July, plots C, E and D had sufficient moisture to provide for ample leaf development and at that time had each a similar area of leaf surface per plant. But plot B received its last irrigation on July second and from the middle of July until harvest suffered to such an extent from low water content that not only was leaf development stopped but the plant had to protect itself by self-pruning its lower leaves. Where the plant had sufficient leaf surface to receive and utilize it, we find, as shown by the temperature curve, that *this factor—energy—increased in intensity up to the end of July and then decreased to the end of the period of growth.*

Influence of Extent of Leaf and Root Surface on Use.—The amount of water transpired by the beet plant will increase as the area of the leaf surface increases. The water supplied to the plant is secured by the porous or uncutinized tips of the fine root hairs. The amount of water secured by the roots in a moist soil depends upon their extent or the area of soil reached by them. Roots secure their energy for growth from the conversion of the foods manufactured in the green leaves. A supply of air in the soil is necessary for this conversion. Therefore, given a proper supply of air and moisture, *the area of the leaf and root surfaces, and consequently the amount of water transpired by the plant, increase from a minimum as the first green leaf emerges from the soil in May to a maximum when the plant is in full leaf in July and August.*

Influence of Amount of Water in Root Zone on Use.—Percolation may account for the larger portion of the moisture lost from the soil zone if excessive amounts of water are applied per irrigation. The maximum amount of water

held per foot in depth of soil for any plot was $4\frac{1}{2}$ inches (see the 6th foot in graphs for plots D and E). This may be considered as the maximum capillary water holding capacity of this soil. Any additional water added to a soil zone already containing this amount of water is not retained but lost by percolation to lower soil zones. Plot E (see graph) contained a high water content throughout the season. The 3rd, 4th, 5th and 6th feet were holding throughout the season so near their utmost capillary capacity that any water percolating to them from irrigations was lost to soil zones below the 6th foot. Plot B had a low water content throughout the season. Very little water reached as far as the fourth foot. *The higher the moisture content of the root zone, the greater the amount of water lost by percolation.* From each irrigation there is some water lost by percolation. This loss of water from the upper soil zones accumulates in the lower zones so long as they are not holding water to their capillary capacity. Thus towards the end of the irrigating season the amount of water in the lower portion of the root zone may have increased to such an extent that percolation loss at this time is much greater than earlier in the season. This is illustrated in the graph for plot C, and will account in part for a higher use of water by this plot in September than the other plots. Plot C was irrigated more often and later in the season than any other plot. The last irrigation, August 19, raised the content of the 5th foot over one inch.

The amount of water transpired by the plant increases as the amount of water in the soil increases. In plots B and D (see graphs) the transpiration, as effected by the amount of water in the soil, increased to the end of July and then decreased from that date to the end of the season. In plots C and E the transpiration as effected by the amount of water in the soil, remained constant or increased slightly after the end of July. The conditions which favour the most rapid use of water—extent of leaf and root surface area, amount of water in root zone, amount of heat, light and energy—gradually increased until they were at their maximum influence in July and produced a use of 8 acre-inches in plot C. The decrease in energy principally, but also the approach of maturity in the plant, account for a decreased use in August. Plot C used 5 inches in this month. A decided drop in temperature with frost on the 23rd reduced the use in September to $3\frac{1}{2}$ inches. One-half inch was used during the first seven days in October.

Conclusions.—The following conclusions of practical value to the sugar beet grower may be drawn from the data presented in the foregoing text and diagrams:—

1. Eighteen to twenty acre-inches of water are required to provide the growing beet crop with an adequate supply of moisture.

2. Of this amount approximately three inches will be required up to June 30, eight inches in July, five inches in August and four inches during the remaining growth period.

3. Soil moisture conditions are most favourable for growth when the pore space or voids of each foot in depth of soil contains from 30 per cent water for fine sandy loam soil to 40 per cent water for silt loam soil. This percentage is equivalent to a water content per foot in depth of $1\frac{1}{2}$ acre-inches for fine sandy soil to a $2\frac{1}{2}$ acre-inches for fine silt loam soil.

4. Beet crops at the Brooks station, where supplied with ample water by irrigation, developed their root system chiefly in the first four feet of soil. The dotted curves on the moisture graphs of each plot show the approximate depth of root feeding zone throughout the season. *This zone did not reach the third foot in depth until July*, and extended only to the fourth foot during the latter part of the season. Under dry farming conditions or where the water supply is limited, beets will develop roots into the fifth and sixth foot but to extend and

grow, *roots must have air and water,* to withhold irrigation under the mistaken impression that it will force the beet to develop a better root system is poor practice. The roots cannot extend unless they have moisture.

5. A study of the four moisture graphs shows that this soil retained in each foot in depth from 1 to 1½ inches of water from each irrigation. Lighter soils retain from ½ to 1 inch. In average practice the irrigator can supply and retain in the soil about 1 inch of water per foot in depth of soil. It is often necessary to irrigate beets about the time of seeding to secure germination or in May or early June to care for the young plants. The root zone at this time is usually within the first two feet of the surface. The irrigator should, therefore, apply a very light irrigation, as near 2 or 3 inches as possible because in the first place the root zone cannot retain more and in the second place excessive irrigation reaches below the root zone the soluble food materials which are less plentiful in the soil at this season and are so much needed by the young plant. As the season develops and the root zone extends in depth, it will utilize greater depths per irrigation but at no time have irrigations in excess of 4 inches proven the most economical.

6. No set rule can be advanced to govern the frequency of irrigation. The root zone must be kept at the proper moisture content by light irrigations. The frequency of these applications will depend upon the rainfall, temperature and growth of the crop. With a rainfall of 7 inches during the 1926 growing season at Brooks, the highest yield was obtained on Plot C, which received a 2-inch irrigation on June 8 and 4 inch irrigations on July 2, July 17, July 31, and August 19. It must be borne in mind that the surface foot or so is the zone containing the most organic material and soil bacteria. It is the principal nitrate factory of the plant. The soil below this zone may have enough water so that the beet plant secures an adequate amount for transpiration but if the food factory gets too dry the plant's growth is retarded. Pot D had plenty of water in the third and fourth feet but an insufficient supply in the upper two feet (see graph D). As a result it produced nearly a ton less per acre than C where the upper two feet had an optimum content to the end of the season.

7. To secure the application of light irrigation the supply ditches should not be over from three hundred to five hundred feet apart, the area irrigated and the stream of water should be measured, the land should be float level, and the furrows should be straight and well made.

DRAINAGE SURVEYS AND INVESTIGATIONS

Drainage administration during the year 1926-27 has been mainly confined to the development of smaller schemes. The department, however, has maintained during the year supervision over the Waterhen Lake Drainage Project in Saskatchewan and the McArthur Land Company's and the Manitoba Dairy Farms' Drainage Projects in Manitoba, as well as keeping in touch with provincial drainage development.

Under the Drainage Regulations provision is made for the drainage of small lakes and sloughs. All applications are investigated by the department and when schemes are determined to be feasible, surveys and plans are prepared and the applicants allowed to purchase the reclaimed lands or to receive title thereto by supplementary patent, depending upon the nature of the ownership of the balance of the quarter-sections affected.

During the year 1926-27 this work has been carried out successfully and considerable progress has been made. There are now some forty-seven small drainage schemes in the Edmonton district and a lesser number in northern Alberta in various stages of completion, while new applications are continually

being made to the Department. It is estimated that in the Edmonton district alone some 5,000 tons of cultivated and improved hay have been harvested this year on the various projects. Some of the older projects are now growing wheat and oats with success.

Provincial Drainage Projects

A number of drainage schemes in the provinces of Alberta and Saskatchewan have been authorized by this department. Drainage districts have since been organized and works constructed under Provincial Drainage laws.

Alberta Provincial Districts.—All of the drainage districts in the province of Alberta are reported to be functioning satisfactorily and generally the financial affairs are in a sound condition. Certain lands in the Viking district purchased from the Dominion Government for one dollar per acre have been sold for the benefit of the district. In the Holden district a program of repair work to ditches will be commenced next year and continued until the whole system is in good condition. A re-assessment of lands in the Daysland district was carried out during the past year and the Board of Trustees had very little trouble from appeals. In the Dickson district the Board of Trustees last year made a start to clean out the ditches where silt and weeds were beginning to cause trouble. During the past year the Dominion Government arranged to transfer to owners of lands in the Hay Lake district the reclaimed Crown fractions of their parcels. This is now being carried out, the owners paying to the Dominion Government one dollar per acre for these fractional areas.

Saskatchewan Provincial Districts.—All work in connection with the two Moose Range districts was completed during the year. Forty-one sections of Crown lands within the district purchased by the province from the Dominion Government were sold at satisfactory prices. The balance of Crown lands purchased will be sold next year. All work on the Naicam district was also completed during the year.

One small drainage district near Lewvan in township 12, range 16, west of the 2nd meridian, was organized during the year and works partially completed. Several new projects were investigated during the year but organization has not yet been completed.

Waterhen Lake Drainage Project

Seeding on the lands in this project was commenced on the 19th of April and completed on the 19th May. This was in advance of the general seeding in the district. Some 1,000 acres were seeded to wheat, 47 acres to oats, 70 acres to flax and 50 acres to wheat and Western Rye grass. All of this crop made such good progress in the early part of the season that a return from twenty to twenty-five bushels to the acre was confidently expected. Unfortunately, however, unfavourable meteorological conditions occurring in August lowered the expected yield very considerably.

Three experimental plots seeded to various grasses, grains and other crops were maintained during the season. Some good results were obtained, especially with respect to sugar beets, mangolds and certain varieties of grasses.

McArthur Land Company's Drainage Project

The balance of the topographical surveys of this project which is situated in townships 16 to 18, ranges 8 to 10, east of Principal meridian, were completed this year, as the result of which it will now be possible to definitely pro-

ject the location of the necessary drainage ditches and canals. Construction of the main outlet canal was commenced.

Manitoba Dairy Farm's Drainage Project

On January 10, 1927, 7,791 acres of Dominion land situated in townships 4 and 5, range 9, east Principal meridian, were leased to the Manitoba Dairy Farms Limited of Marchand, Man., for reclamation by drainage, for a period of twenty years. The company is carrying out the necessary field surveys upon which the plans required to be filed in the department will be based.

Application for water-power privileges throughout the Dominion should be made direct to the following administrative officers of the Dominion and the various Provincial Governments:

Province of British Columbia: The Comptroller of Water Rights, Department of Lands, Victoria, B.C.

Provinces of Manitoba, Saskatchewan and Alberta, the Yukon and the Northwest Territories: The Director of Water Power and Reclamation, Ottawa, Ont.

Province of Ontario: The Deputy Minister of Lands and Forests, Toronto, Ont.

Province of Quebec: The Chief Engineer, Hydraulic Service, Department of Lands and Forests, Quebec, Que.

Province of New Brunswick: The Chairman of the New Brunswick Electric Power Commission, St. John, N.B.

Province of Nova Scotia: The Chairman of the Nova Scotia Power Commission, Halifax, N.S.

Province of Prince Edward Island: The Provincial Secretary-Treasurer, Charlottetown, P.E.I.

For general information regarding the water-powers of the Dominion, application should be made to the Director of Water Power and Reclamation, Department of the Interior, Ottawa.

CLASSIFIED LIST OF PUBLICATIONS

DOMINION WATER POWER AND RECLAMATION SERVICE
ANNUAL REPORTS

Annual Reports previous to 1913 are included with the Annual Report of the Department of the Interior, and can be secured from the secretary of the department.

Annual Reports for the fiscal years ending March 31, from 1914 to 1927, are available for distribution. That for 1924 is the first report combining the activities of the Water Power and Reclamation divisions of the Service.

WATER POWER

(Water Resources Papers)

REPORTS OF SPECIAL OR GENERAL INTEREST

Water Resources Paper No. 2.—Report on Bow River Power and Storage Investigations, Bow River west of Calgary, by M. C. Hendry, chief engineer in charge of surveys. This is a complete study of the Bow river west of Calgary. It deals with meteorological conditions and their effect on run-off and ice formation. Existing and possible power and storage developments, together with maps and plans are appended complete. Published 1914. Out of print.

Water Resources Paper No. 3.—Report on Power and Storage Investigations, Winnipeg River, by J. T. Johnston, chief hydraulic engineer, Dominion Water Power Branch. A complete study based on field surveys and office computations of the Winnipeg River basin; deals fully with history, international considerations, topography, climate, storage possibilities; describes existing and gives preliminary designs and estimates for possible power developments; discusses other sources of power and the power market. Maps, plans and all relevant data are appended. Published 1915. Out of print.

Water Resources Paper No. 5.—Preliminary Report on the Pasquia Reclamation Project, by T. H. Dunn, chief engineer in charge of Reclamation Survey. This is a progress report of investigations carried out to determine the possibility of lowering the level of Cedar lake and its effect in a general scheme for reclaiming the low-lying lands contiguous to the Saskatchewan river in the Pasquia region. Published 1914. Out of print.

Water Resources Paper No. 6.—Report on cost of various sources of power for pumping in connection with the South Saskatchewan Water Supply Diversion Project, by H. E. Kensit. It deals with the problem of power for pumping water from the South Saskatchewan river for the supply of cities and towns in the central portion of South Saskatchewan. Published 1914. Out of print.

Water Resources Paper No. 7.—Report on the Manitoba Water Powers, by D. L. McLean, S. S. Scovil and J. T. Johnston, compiled for the Manitoba Public Utilities Commission. A general survey of the water-power situation in Manitoba, with all available general information and hydrometric data published to date in condensed form concerning the rivers in Manitoba. Published 1914. Replaced by No. 56.

Water Resources Paper No. 10.—General Guide for Compilation of Water Power Reports of the Dominion Water Power Branch, prepared for the guidance of field engineers of the Dominion Water Power Branch, by J. T. Johnston, chief hydraulic engineer. Published 1915. Limited edition.

Water Resources Paper No. 11.—Second Report on the Pasquia Reclamation Project by T. H. Dunn, chief engineer in charge of Reclamation Survey. This is a continuation Report based on further investigations as outlined under Water Resources Paper No. 5. Published 1915. Out of print.

Water Resources Paper Po. 12.—Report on Small Water Powers in Western Canada, and discussion on sources of power for the Farm, by A. M. Beale. Part I is a brief description of certain small western water-power developments. Part II gives an analysis of requirements and cost data for the farm power supply. Published 1915. Out of print.

Water Resources Paper No. 13.—Report on the Coquitlam-Buntzen Hydro-Eletric Development. A complete description of the project and of the details of construction, with plans, diagrams and illustrations, by G. R. G. Conway, chief engineer of the British Columbia Electric Railway Company, Limited. Published 1915.

Water Resources Paper No. 16.—Water Powers of Canada. A series of five pamphlets in one volume covering the water-power situation in Canada, prepared for distribution at the Panama Pacific Exposition, San Francisco, 1915, by G. R. G. Conway, consulting engineer, Toronto; Percival H. Mitchell, consulting engineer, Toronto; H. G. Acres, hydraulic engineer, Hydro-Electric Power Commission, Ontario; F. T. Kaelin, assistant chief engineer, Shawinigan Water and Power Co., Montreal; K. H. Smith, engineer, Nova Scotia Water Power Commission, Halifax, N.S. Published 1916. Out of print.

Water Resources Paper No. 17.—Canadian Hydraulic Power Development and Electric Power in Canadian Industry, by Charles H. Mitchell, consulting engineer to Dominion Water Power Branch. Part I deals with progress of utilization, features in design, construction and operation specially applicable to Canada. Description of certain typical Canadian water-power developments. Part II analyses the uses, growth and future of electrical power in Canadian industry. Published 1916. Out of print.

Water Resources Paper No. 20.—Report on the Interests Dependent on Winnipeg River Power, with Special Reference to the Capital Invested and the Labour Employed, by H. E. M. Kensit. A detailed study of the industrial growth and future power requirements of the district tributary to the Winnipeg River power sites. Published 1917. Out of print.

Water Resources Paper No. 27.—Directory of Central Electric Stations in Canada to January 1, 1919, compiled by J. T. Johnston, assistant director, Dominion Water Power Branch. Comprises an analysis of the central electric census statistics and a directory of the stations. Published 1919. Out of print.

Water Resources Paper No. 32.—Water Resources Index Inventory, by J. T. Johnston. Description of the Index Inventory System for recording and collating the water resources data of the Dominion. Published 1922. Out of print.

Water Resources Paper No. 33.—Directory of Central Electric Stations in Canada, to November 1, 1922. Comprises an analysis of the central electric station statistics and a directory of the stations. Published 1923. Price, 50 cents.

Water Resources Paper No. 55.—Directory of Central Electric Stations in Canada. In course of preparation.

Water Resources Paper No. 56.—Water Powers of Manitoba. Administration, developed power and available undeveloped power, by C. H. Attwood, district chief engineer. Published 1926.

Water Resources Paper No. 60.—Water Powers of Canada. A general review of the water-power resources of Canada as to investigation, administration, developed power, use of power in industry and available undeveloped power, by J. T. Johnston, Director of Water Power and Reclamation. Published 1927.

SURFACE WATER SUPPLY REPORTS

ATLANTIC DRAINAGE SOUTH OF ST. LAWRENCE RIVER INCLUDING NOVA SCOTIA, NEW BRUNSWICK, PRINCE EDWARD ISLAND, AND SOUTHEASTERN QUEBEC

Water Resources Papers Nos. 29, 37, 45 and 52.—Surface water supply of Canada. Reports on hydrometric surveys covering the Atlantic drainage south of the St. Lawrence river, including Nova Scotia, New Brunswick, Prince Edward Island and southeastern Quebec, for the climatic years ending September 30, 1919 to 1926, by K. H. Smith and K. G. Chisholm, district chief engineers.

ST. LAWRENCE AND SOUTHERN HUDSON BAY DRAINAGE IN QUEBEC

Water Resources Papers Nos. 41, 48 and 57.—Surface water supply of Canada. Reports on hydrometric surveys covering the St. Lawrence and southern Hudson Bay drainage in Quebec for the climatic years ending September 30, 1923 to 1927, by Leo G. Denis, district chief engineer. No. 57 is in course of preparation.

ST. LAWRENCE AND SOUTHERN HUDSON BAY DRAINAGE IN ONTARIO

Water Resources Papers Nos. 28, 34, 38, 42, 49 and 58.—Surface water supply of Canada. Reports on hydrometric surveys covering the St. Lawrence and southern Hudson Bay drainage in Ontario for the climatic years ending September 30, 1920 to 1927, by S. S. Scovil, district chief engineer. No. 58 is in course of preparation.

ARCTIC AND WESTERN HUDSON BAY DRAINAGE (AND MISSISSIPPI DRAINAGE IN CANADA) IN ALBERTA, SASKATCHEWAN, MANITOBA, EXTREME WESTERN ONTARIO, AND NORTHWEST TERRITORIES

Water Resources Papers Nos. 4, 19, 22, 24 and 26.—Surface water supply of Canada. Reports on hydrometric surveys in Manitoba, from January 1, 1912, to September 30, 1919, by M. C. Hendry and C. H. Attwood, chief engineers. No. 4 contains a gazetteer of lakes and streams in Manitoba.

Water Supply Bulletins Nos. 1 to 11.—Surface water supply of Canada. Reports on hydrometric surveys in Alberta and Saskatchewan from 1908 to September 30, 1919, by P. M. Sauder and A. L. Ford, chief hydrometric engineers, Reclamation Service. Out of print.

Water Resources Papers Nos. 31, 36, 40, 44, 46, 50 and 54.—Surface water supply of Canada. Reports on hydrometric surveys covering the Arctic and western Hudson Bay drainage (and Mississippi drainage in Canada) in Alberta, Saskatchewan, Manitoba, extreme western Ontario and the Northwest Territories, for the climatic years ending September 30, 1920 to 1926, by C. H. Attwood and A. L. Ford, district chief engineers.

PACIFIC DRAINAGE IN BRITISH COLUMBIA AND THE YUKON TERRITORY

Water Resources Papers Nos. 1, 8, 14, 18, 21, 23, 25, 30, 35, 39, 43, 47, 51 and 53.—Surface water supply of Canada. Reports on hydrometric surveys covering the Pacific drainage in British Columbia and the Yukon Territory from May, 1911, to September 30, 1926. No. 1 is by P. A. Carson, chief engineer, the others by R. G. Swan and C. E. Webb, district chief engineers. No. 1 contains an outline of the history of the Railway Belt with special reference to its administrative, legal and physical problems in regard to water, and a gazetteer of the lakes and streams in British Columbia.

MAP

Water Power of the Dominion of Canada prepared in connection with the First World Power Conference, London, Eng., 1924.

RECLAMATION

Drainage Regulations.

Irrigation Regulations.

Annual Irrigation Reports.—1894-1911. (Out of print.)

Annual Irrigation Reports—Calendar years 1912 to 1915. (Out of print.)

Irrigation Surveys and Inspections Report—Fiscal years 1915-16, 1916-17, 1917-18, 1918-19. (Out of print.)

Annual Report of the Reclamation Service—1919-20, 1920-21, 1921-22, 1922-23.

Annual Report of the Water Power and Reclamation Service 1923-24, 1924-25, 1925-26, 1926-27.

Annual Stream Measurement Reports of Alberta and Saskatchewan—Water Supply Bulletins Nos. 1-11, 1909-1919. (Out of print.) (Continued in Water Resources Papers Nos. 31, 36, 40, etc.).

Western Canada Irrigation Association Reports—(1st to 11th Convention, 1907-1917). (Out of print.)

International Irrigation Congress Report (1914).

Bulletin No. 1—Irrigation in Alberta and Saskatchewan. (Consisting of a Synopsis of the Irrigation Act and its Administration.)

Bulletin No. 2—Alfalfa Culture. (Out of print.)

Bulletin No. 3—Climatic and Soil Conditions, C.P.R. Irrigation Block.

Bulletin No. 4—Duty of Water Experiments and Farm Demonstration Work. (Out of print.)

Bulletin No. 5—Farm Water Supply.

Bulletin No. 6—Irrigation Practice and Water Requirements for Crops in Alberta. (Out of print.)

Pamphlets:

Address by Mr. S. G. Porter—"Practical Operation of Irrigation Works."—Extract from W.C.I.A. Report, 1914.

Address by Dr. Rutherford—"Inter-dependence of Farm and City."—Extract from W.C.I.A. Report, 1914.

Address by Mr. Don. H. Bark—"The Actual Problem that Confronts the Irrigator."—Extract from W.C.I.A. Report, 1914.

Address by Mr. Don. H. Bark—"Practical Irrigation Hints for Alberta."—Extract from W.C.I.A. Report, 1915.

Address by Mr. Don. H. Bark—"Alfalfa Growing."—Extract from W.C.I.A. Report, 1915.

"Practical Information for Beginners in Irrigation" (by W. H. Snelson, A.M.E.I.C.).

Dept. of the Interior
Dominion Water Power
& Reclamation Service
1926-27

Dept. of the Interior
Dominion Water Power &
Reclamation Service
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Water Resources Papers, and Irrigation and Drainage Reports, as listed at the end of this report are issued gratis, with the exception of Water Resources Paper No. 33, for which a charge of 50 cents is made. These can be had on application to the Director of Dominion Water Power and Reclamation Service, Department of the Interior, Ottawa

DEPARTMENT OF THE INTERIOR, CANADA
HON. CHARLES STEWART, Minister; W. W. CORY, C.M.G., Deputy Minister

DOMINION WATER POWER AND RECLAMATION SERVICE
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FOR THE

Fiscal Year Ended March 31, 1928

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INTRODUCTORY

ORGANIZATION

International Waterway Matters.—The organization of the Dominion Water Power and Reclamation Service in field and office is such as to facilitate the ready compilation and analysis of run-off and other hydrometric and hydraulic data on boundary waters and on waters flowing into boundary waters along the international boundary between Canada and the United States. Because of its facilities the service has been charged with the responsibility of securing such data and of making such studies as are necessary for an intelligent consideration of all matters affecting boundary waters, and of advising the Minister with respect thereto.

Water-Power.—The water-power activities are both administrative and investigatory. The proprietary interest of the Dominion in the water resources of Alberta, Saskatchewan and Manitoba, of the Northwest and Yukon Territories and of the Railway Belt in British Columbia gives rise to the necessity of administering these resources in accordance with the Dominion Water Power Act and the Regulations thereunder, and places upon this Service the responsibility of securing such fundamental engineering and economic data as will enable it to properly control the development, distribution and sale of hydro-electric energy.

Throughout the rest of Canada the water-powers are vested in the Provinces, and investigatory work is carried on in co-operation with the respective provincial authorities charged with the administration of these resources. The Service also co-operates extensively with other federal departments and commissions making the services of its field engineering staff available to these organizations, when, in the interests of general economy and efficiency, it is desirable to do so.

The co-operative water-power and hydrometric survey work is undertaken through district offices, each in charge of a District Chief Engineer, located as follows: British Columbia, at 739 Hastings Street West, Vancouver; Alberta and Saskatchewan, at Southam Chambers, Calgary; Manitoba, at 706 Commercial Building, Winnipeg; Ontario, the local organization has headquarters at the Ottawa office of the service; Quebec, at 961 Inspector Street, Montreal; The Maritime Provinces, at 193 Hollis Street, Halifax. In every case the district offices are operated in the closest co-operation with the provincial offices engaged in the administration or use of water or water-power.

In the Yukon and Northwest Territories the water-power resources are administered from Ottawa, and, in the case of the Yukon, through the Gold Commissioner at Dawson. Investigatory work in the Yukon is handled through the British Columbia organization and in the Northwest Territories as the exigencies of the situation demand.

The water-power field organization is based upon and built up around the Dominion Hydrometric Survey staff, through which systematic and continuous stream measurement studies are carried on throughout the Dominion. The data secured by the hydrometric staff and through the co-operative efforts of

the various provincial and other organizations are collated, analyzed and standardized at the head office of the Service at Ottawa, with the result that there is already available in Ottawa both general and detailed information concerning the run-off and power possibilities of the more important power rivers throughout Canada. These data are constantly being revised as new or later information is received and are promptly available for reference to all interested in the utilization of the water-powers of the Dominion.

Irrigation and Drainage.—The surface waters in the provinces of Alberta, Saskatchewan, northern Manitoba and the Northwest Territories are administered by the federal Government under the Irrigation Act. All matters that affect the control of water supply generally, as well as the inspection and authorization of works for the use of water for domestic, municipal, industrial and irrigation purposes and the granting of the licenses for such purposes are dealt with thereunder. Every endeavour is made to administer the water supply so that the greatest benefit may result to the public. The Commissioner of Irrigation at Calgary, Alberta, is responsible for all field administration.

The Reclamation Act and Regulations having to do with the reclamation of lands by drainage are administered along similar lines. Any questions of drainage affecting federal interests in the provinces of Manitoba and British Columbia to which the Irrigation Act does not apply, are dealt with through the agency of the District Chief Engineers of this Service in those provinces. Close co-operation is at all times maintained with the provincial drainage authorities.

PUBLICATIONS

A list of the Annual Reports, Water Resources Papers and Reclamation Reports published to date will be found at the end of this report, and copies of those which are still available for distribution will be sent on application to those interested, free of charge, except in the case of the Directory of Central Electric Stations in Canada, for which a charge of fifty cents is made.

During the past year the Annual Report for the fiscal year 1925-26 and Water Resources Papers Nos. 50, 52, 53 and 60 were published. The Annual Report for 1926-27, Water Resources Paper No. 54 and the Interim Report of the Special International Niagara Board are now in press. Bulletins were issued dealing with hydro-electric progress in Canada during 1927 and the water-power resources of Canada as at January 15, 1928.

PART I

INTERNATIONAL WATERWAY MATTERS

During the year International Waterway problems continued to receive close consideration, and appropriate action was taken from time to time in connection with the various matters arising.

The special International Niagara Board, appointed by the Government of Canada and the United States to determine how the scenic beauty of Niagara falls and rapids can best be maintained and by what means and to what extent the impairment thereof by erosion or otherwise can be overcome and, consistent with the preservation of the scenic beauty of the falls and river, to determine what quantity of water might be diverted from the river for power purposes, submitted to the two Governments on December 14, 1927, an interim report recommending the early construction of certain initial remedial works designed to rewater the presently bared flanks of the Horseshoe falls, to ensure an adequate supply of water to the rapids in the vicinity of the Three Sisters islands and a dependable flow over the American falls.

Following the submission of the interim report the board continued its compilation and study of the basic data underlying the problem, preparatory to formulating its final report.

The suit between the compainant states of Wisconsin, Minnesota, Pennsylvania and Ohio *vs.* The Chicago Sanitary District, before the United States Supreme Court, in reference to the diversion of water from the Great Lakes system through the Mississippi watershed, has been closely followed, in view of its importance to Canadian interests. Following various hearings held by Special Master Charles E. Hughes, oral argument was presented on May 31st, June 1st, 2nd and 3rd, 1927, and Mr. Hughes' report to the United States Supreme Court was made on November 23, 1927. On June 3, the Supreme Court allowed thirty days in which exceptions to the Special Master's finding might be filed. The complainant states filed their exceptions and a further hearing will be held at an early date before the Supreme Court of the United States at which the contending parties will present their final argument. The court's decision may be expected on some date following the hearing of the final arguments.

The Lake of the Woods Convention between Canada and the United States, executed on February 24, 1925, embodied a number of provisions which require departmental action. The Canadian Lake of the Woods Board has continued its regulation of Lake of the Woods between elevations 1056 and 1061 sea level datum, as elsewhere recorded in this report. The International Lake of the Woods Board, appointed under the Convention, is called upon to exercise its responsibilities whenever the lake rises above elevation 1061 or falls below elevation 1056 sea level datum. On the 22nd of April last, the abnormally high water conditions in the watershed resulted in the lake rising above the upper limit and the International Board accordingly automatically took over the regulation. The board exercised its regulatory control until the 15th of August, on which date the lake had dropped to elevation 1061 and the Canadian Board resumed its control. In accordance with the requirements of the Convention the International Board, in July 1927, approved the plans of the reconstructed Norman dam and of the enlargement of the Western Outlet from the lake.

The Convention also provides for the securing of flowage easement up to elevation 1064 on the United States shores of Lake of the Woods. Officials of the department have been, during the past season, in active co-operation with the United States officers charged with the responsibility for carrying out this provision of the Convention.

Incorporated in the Lake of the Woods Convention is the Rainy Lake Reference to the International Joint Commission, which has to do with the provision of storage in Rainy lake and in the boundary waters above, and with the development of power in connection therewith. Intensive field and office investigatory work in connection with this Reference has been under way during the year and excellent progress has been made. The investigations will be continued during the forthcoming season.

The St. Lawrence River Power Company filed with the United States War Department, on June 9, 1927, an application to raise the crest of the company's existing submerged weir in the South Sault channel of the St. Lawrence river near Massena, N.Y., and in January, 1928, the company's application was filed with the International Joint Commission. The commission has arranged for a hearing on the company's application, to be held upon the occasion of the April meeting of the commission in Washington.

The Creston Reclamation Company, on October 14, 1927, submitted a formal application to the International Joint Commission for approval to its project for the reclamation by dyking on 8,600 acres of land in Kootenay Flats on the Kootenay river. The commission held a hearing re this matter on November 29, 1927, at Nelson, British Columbia, at which all parties interested submitted representations. The issuance of the commission's order was withheld to permit of further investigations being made.

Other international problems have been active, such as those in connection with drainage and flooding on the Roseau river in Manitoba, and the Columbia River Reclamation Project in the United States and its effect upon the Pend d'Oreille river in British Columbia.

The various International Waterway Boards have functioned as usual throughout the year.

In accordance with the rulings of the International Joint Commission made on October 4, 1921, in conformity with the Boundary Waters Treaty of 1909, the measurement and apportionment of the stream flow in the St. Mary and Milk rivers and their tributaries in the provinces of Alberta and Saskatchewan and in the state of Montana, were continued throughout the past year by an engineer of this service, in co-operation with an engineer of the United States Reclamation Service. The report covering the year's operation has been prepared and submitted to the commission for review upon the occasion of its regular semi-annual meeting in April.

The International Lake Superior Board of Control continued to exercise its responsibilities with respect to the regulation of lake Superior throughout the year. Records of discharge through the rapids, navigation canals and power plants on both sides of the river were systematically reported to the board. The precipitation of the Lake Superior basin continued the marked improvement which began in 1926. The influence of this increased precipitation is apparent in the gradual bettering of the lake levels. During the year the repainting and re-conditioning of the Canadian section of the control dam was completed, following the completion of similar work on the United States end of the dam in 1926. The work of recalibrating the sluices of the control dam and other outlets was continued.

The International Niagara Board of Control has continued its close regulation of the diversions from the Niagara river for power purposes as permitted by Article V of the Boundary Waters Treaty. Continuous records of the

withdrawal of water by all power stations on both sides of the river are obtained by the board, and the control exercised is such as to ensure that the limits of diversion set forth in the treaty are not exceeded.

Conditions obtaining with respect to the submerged weir in the South Sault channel of the St. Lawrence river and the regulation of flow through the Massena canal were subject to the supervision of the International Massena Board of Control throughout the year, in accordance with the order of the International Joint Commission dated December 6, 1922. The board was in receipt of monthly reports showing the amount of water diverted and the power-house performance from day to day. No abnormal conditions developed during the year.

The International St. Croix River Board of Control continued to exercise its supervision over the discharge of the St. Croix river past the Grand Falls dam, in accordance with the orders of the International Joint Commission dated November 9, 1915, and October 3, 1923. The board was in receipt of systematic reports of the discharge of the river and of the water elevations above and below the Grand Falls dam. No abnormal conditions developed during the year. A satisfactory flow of water has been maintained in the river below the dam for the benefit of the power users and for the supply of water for the fishways.

PART II

WATER POWER

LAKE OF THE WOODS CONTROL BOARD

The Director of the Dominion Water Power and Reclamation Service and the Chief Engineer of the Department of Public Works, represent the Dominion Government on the Canadian Lake of the Woods Control Board. The province of Ontario is represented by provincial officials. The responsibilities of the board are concerned with the regulation of the levels and outflow of lake of the Woods and for the proper performance of these duties the collection of hydrological data relating to the watershed is pre-requisite. The board is now deriving the benefit of comprehensive basic records which have been gathered by Dominion officials over a period of years.

During the fiscal year the board was called upon to regulate the levels and outflow of the lake in the face of the highest flood inflows on record.

The lake of the Woods had reached elevation 1060·01 on the 1st April, 1927, and, in spite of continued increases of the regulated outflow, the level rose above elevation 1061·00 on the 22nd of April. By virtue of the provisions of the Lake of the Woods Convention, the regulation of the lake on reaching this elevation automatically passed into the hands of the International Lake of the Woods Control Board. Close co-operation was maintained between the Canadian and the United States members of the International Board and Dominion officials continued to operate the control structures at the lake's outlets under the International Board's supervision. With the whole watershed in a state of flood, high inflows continued until lake level had risen to a maximum elevation of 1062·90 on the 1st of June. Subsequent to this date the inflows gradually decreased and by maintaining maximum outflow rates lake level was gradually brought down until it passed below elevation 1061·00 on the 15th of August, and the regulation of the lake reverted to the Canadian Board. The rate of outflow was at once reduced but it was necessary to maintain a comparatively high rate of outflow throughout the balance of the year in order to keep lake level below the upper storage limit and to provide a safety margin of storage capacity to handle possible high spring inflows. On the 31st of March, 1928, lake level was at elevation 1060·10 and there was no indication of a recurrence of the excessive run-off conditions of the past year.

Throughout the fiscal year and especially during the flood period the board was indebted to the Department of Public Works for run-off records on Rainy and Namakan lakes, and to the Dominion Meteorological Service and the United States Meteorological Service for precipitation records at the numerous stations throughout the watershed.

In November the second stop-log winch was installed for the operation of the sluices in the southern end of the Norman dam, making possible the efficient control of level and outflow, in accord with treaty stipulations with the Government of the United States.

WATER-POWER REGULATIONS AND LEGAL RESEARCH

While no new rights have been granted under the Dominion Water Power Regulations during the past year, several licences, based upon applications for water-power developments, have been prepared and are awaiting executive action.

The study of water-power administration as shown by provincial legislation and jurisprudence has been continued and a large amount of material collected and analysed. The scope of the inquiry has been extended to include interprovincial and international rights to the use of boundary waters.

BRITISH COLUMBIA ADMINISTRATION

The waters in the Railway Belt of British Columbia are administered by the province in accordance with the Railway Belt Water Act, passed by the Parliament of Canada in 1912 and amended in 1913, 1926 and during the present session. The plan adopted by Parliament is that these waters are administered under the provincial laws so as to secure a system of granting water privileges uniform throughout the province.

The waters in the Railway Belt, however, together with the ungranted Crown lands therein, are public property of the Dominion, and for that reason the water privileges granted by the province in the Belt are examined in this Department for the due protection of Dominion interests. Rights in Dominion lands required to be used or occupied in connection with grants of water are issued by the Department in accordance with the Water Lands Regulations.

Applications for water rights required for the improvement of Indian reserves throughout the province are prepared by officers of this service, and surveys and investigations made in furtherance of those applications where necessary. Evidence in support of Indian claims to the use of water is also prepared and assistance given in connection with the hearing of such claims before the Board of Investigation under the Water Act.

ENGINEERING CO-OPERATION WITH DEPARTMENT OF INDIAN AFFAIRS

At the request of the Department of Indian Affairs and under the direction of the District Chief Engineer at Winnipeg, repairs were made to the water supply system of the Sioux Lookout Indian school and a report prepared as to the condition of the sewage system at the MacIntosh Indian school, both in Ontario. In Manitoba, a report was prepared on the reclamation of marsh areas in the Peguis Indian Reserve, repairs made to the sewage system at Sandy Bay Indian school, and the water supply system at the Fort Alexander school, also a report made on the water supply of the Guy school near Sturgeon Landing.

Under the direction of the Commissioner of Irrigation, plans and specifications were prepared for the water supply and sewage systems at the new Onion Lake school in Saskatchewan. Tenders have been called and it is expected that the work, to cost about $14,000, will be completed during the coming summer.

As in previous years, the local staff of the service in British Columbia have conducted a number of investigations and supervised the construction of important irrigation and other improvements in connection with Indian reserves, villages and schools. The investigations carried out numbered 28, of which 17 were for irrigation schemes and improvements, water supply 8, electric lighting systems 2, and 1 in connection with erosion by stream flow. There were 27 separate construction projects under supervision of the local engineers of the service, not all of which were completed at the end of the fiscal year. Of these

17 were irrigation and storage projects, 7 water supply systems, 2 sewage disposal and 1 electric lighting system. The total cost of these improvements was slightly over $32,000, which is small as compared with the benefits derived from them.

Further details as to this co-operative work will be found in the reports of the District Chief Engineers of the western provinces.

WATER RESOURCES INDEX INVENTORY

The Index Inventory system for recording and collating the water-resources data of the Dominion has been in actual use for a number of years and has provided a most efficient method for the referencing, analysis, standardization and filing of all data relating to the subject of water resources. A detailed description of the system has appeared in the Annual Report for 1916-17 and in the combined reports for the years 1917-18-19.

The system has been applied to practically all phases of the work carried on by the service, among the more outstanding of which may be mentioned the complete census of developed water power, the analysis of central electric station activities, undeveloped water-power resources, stream measurement activities and storage investigations.

This work has been largely carried on in co-operation with provincial organizations, notably the Hydro-Electric Power Commission of Ontario, the Quebec Streams Commission, the British Columbia Water Rights Branch, the Nova Scotia Power Commission and the New Brunswick Electric Power Commission. The data compiled are being continually revised in accordance with the most up-to-date information and, resulting from a number of years of effort, a very large amount of information in standardized form is now available.

WATER-POWER RESOURCES OF CANADA

In common with the stock-taking which takes place in most industrial and other undertakings at the beginning of the new year, it is the custom of this service to make an annual inventory of Canada's water-power resources in order that accurate information as to the total available and developed water-power of the country may be kept thoroughly up-to-date and available for public reference. The review which follows takes account of the increase in water-power installation which was made in 1927 and also a reanalysis of available power in certain districts which had the effect of increasing the total available power figures hitherto published for the Dominion.

With the installation during the past year of new water-power equipment of more than 221,000 horse-power there is now installed for all purposes a total of 4,777,921 horse-power and by the completion of work now under way this figure will be increased to more than 5,100,000 before the end of 1928.

While complete data regarding Canada's great water-power resources are not yet available, a great quantity of reasonably accurate, together with many specific data, has been collected. All existing stream-flow and power data available from federal, provincial and private sources have been systematically collated, analysed and co-ordinated with a view to presenting a dependable estimate of available power based on uniform methods of computation and arrangement.

During the past year a re-analysis of the power possibilities in various districts has resulted in an increase in the total estimated available figures for the Dominion in spite of the fact that a recent judgment of the Privy Council

takes from Canada a considerable area of north-eastern Quebec in which large water-powers are located. The most recent figures for the Dominion indicate the total resources to be 20,197,000 horse-power under conditions of ordinary minimum flow or 33,113,000 horse-power ordinarily available for six months of the year. These figures are of course subject to revision as more and more is learned of the flow characteristics and physical conditions of the streams throughout the country.

Basis of Computation

The figures for available water power listed in Table 1 are based upon rapids, falls and power sites of which the actual existent drop or the head possible of concentration, is definitely established or at least well authenticated. Many rapids and falls of greater or lesser power capacity are scattered on rivers and streams from coast to coast which are not as yet recorded, and which will only become available for tabulation as more detailed survey work is undertaken and completed. This is particularly true in the relatively unexplored northern districts. Nor is any consideration given to the power concentrations which are feasible on rivers and streams of gradual gradient, where economic heads may be created by the construction of power dams, excepting only at such points as definite studies have been carried out and the results made matters of record.

In brief, the figures hereunder are based on definite rapids, falls and power sites, and may be said to represent the *minimum water power possibilities of the Dominion.*

The power estimates have been calculated on the basis of 24-hour power at 80 per cent efficiency for conditions of " Ordinary Minimum Flow" and " Ordinary Six Months Flow ". The " Ordinary Minimum Flow " is based on the averages of the flows for the two lowest periods of seven consecutive days in each year, over the period for which records are available. The " Ordinary Six Months Flow " is based upon the continuous power indicated by the flow of the stream for six months in the year. The actual method to determine this flow is to arrange the months of each year according to the day of the lowest flow in each. The lowest of the six high months is taken as the basic month. The average flow of the lowest seven consecutive days in this month determines the ordinary six months flow for that year. The average of such figures for all years in the period for which data are available is the ordinary six month flow used in the calculation.

Estimates of power on the basis of ordinary six-month flow are made upon the assumption that it is good commercial practice to develop wheel installation up to an amount, the continued operation of which can be assured during six months of the year, with the deficiency in power during the remainder of the year provided from storage not yet created or by the installation of fuel power plants as auxiliaries. The correctness or otherwise of this assumption for any particular site can only be definitely settled by careful consideration of all circumstances and conditions pertinent to its development. The method, however, enables a fairly satisfactory overall estimate of the maximum hydraulic power available, to be made as distinctive from the estimated ordinary minimum power available.

Available and Developed Totals

The known available water-power in Canada, from all sources and within the limitations outlined, is 20,197,000 horse-power for conditions of ordinary minimum flow and 33,113,200 horse-power ordinarily available for six months of the year.

It is believed that these are conservative estimates since an analysis of the water-power plants scattered from coast to coast concerning which complete data are available as to turbine installation and satisfactory information as to stream flow, gives an average machine installation 30 per cent greater than the ordinary six-month flow of power. Applying this, the figures quoted above, therefore, indicate that the present recorded water-power resources of the Dominion will permit of a turbine installation of approximately 43,000,000 horse-power.

The total installation to date in waterwheels and turbines throughout the Dominion is 4,777,921 horse-power. In other words the present turbine installation represents only a little over *11 per cent* of the recorded water-power resources.

Current Progress in Development

Throughout the Dominion the activity in hydro-electric and water-power development that has been manifest during the past few years, continued without abatement during 1927 and sufficient undertakings are either under construction or in early prospect to ensure substantial progress being maintained in 1928 and the years following.

This is indicated in the following review which shows that in 1927 hydro-power equipment was installed ready for operation to the extent of 221,655 horse-power while other undertakings were advanced to such a stage that a further total of 378,000 horse-power will be in place during the first six or seven months of 1928. With the additions during the year the total installation in Canada has grown to a figure of 4,777,921 horse-power at the end of 1927 which will shortly be raised to more than 5,100,000 by the installations now in process of completion. It is interesting to record that the latter figure is just double the total installation in Canada at the end of the year 1920, a remarkable growth in the short period of seven years.

Additional to the undertakings which are nearing completion, there are a number in the initial stages of construction and others about to be commenced, which will result in an addition to the total installation in the Dominion of more than 2,000,000 horse-power, much of which, it is expected, will be in place before the end of 1930. This new work will require at the very least a direct investment of more than $200,000,000.

The most significant feature of progress during 1927 was undoubtedly the advance into higher voltages for long distance electric power transmission. In this regard the Shawinigan Water and Power Company was the pioneer in constructing a line of higher potential than 110,000 volts in the 135-mile, 165,000-volt line built and brought into operation during the year to carry 100,000 horse-power from Isle Maligne on the Saguenay river to Quebec city. Another line of still greater voltage was commenced by the Ontario Hydro-Electric Power Commission to transmit power more than 200 miles from the Gatineau river in Quebec to the city of Toronto. This line is designed to carry more than 250,000 horse-power at 220,000 volts and it is expected will be brought into operation about September of 1928.

Among large installations during the year, the review by provinces which follows indicates that the most outstanding were those of the Gatineau Power Company on the Gatineau River in Quebec province where two plants having initial installations of 102,000 horse-power and 72,000 horse-power were brought into operation. Other installations of note were those of the British Columbia Electric Railway Company on Stave lake, B.C., with 12,500 horse-power, the Manitoba Power Company with an addition of 28,000 horse-power at Great

Falls on the Winnipeg river, the Ontario and Minnesota Power Company with two new plants on the Seine river of 10,000 horse-power and 14,420 horse-power respectively and the Sandy Lake development of the Nova Scotia Power Commission with 5,000 horse-power installed.

British Columbia.—In British Columbia the principal activities of the year were carried out by the West Kootenay Power and Light Company and by the subsidiaries of the British Columbia Electric Railway Company, viz—the Burrard Power Company, Limited, the Vancouver Island Power Company, Limited, and the Bridge River Power Company, Limited.

The Burrard Power Company, Limited, completed the construction of the power station at the outlet of the Alouette Stave tunnel on the shore of Stave lake and the turbine of 12,500 horse-power was in place before the end of the year. The electrical machinery was also being installed and is expected to be in operation by March, 1928. A feature of special interest in connection with this plant is that it is to be operated by remote control from the Stave Falls plant.

The Vancouver Island Power Company, Limited, following the increase in storage made during 1926 in its Jordan River development, achieved considerable progress in the reconstruction of the flume carrying water to the power station. The capacity of the flume is being raised from 162 to 257 cubic feet per second.

The Bridge River Power Company, Limited, carried on extensive preparatory work in connection with the Bridge River project which, when completed, will be the largest development in the province. Roads, camps and construction plant were proceeded with and early in October a contract was awarded for the construction of the tunnel leading from Bridge river to the power station site on Seton lake. This tunnel will be 13,200 feet in length and 12 feet in diameter. Camps have been installed by the contractor at both portals and excavation work is under way. It is planned to have the initial installation of two 28,000-horse-power units completed by the end of 1930.

The West Kootenay Power and Light Company actively carried forward the construction of its now 60,000-horse-power development on the Kootenay river at South Slocan. Excavation work is almost completed and concrete work well under way. It is expected that the plant will be completed towards the end of 1928.

The same company has plans under preparation and is seeking authority for the construction of a dam at the outlet of Kootenay lake to effect a storage range of 6 feet on that lake. Such storage would increase the output of the company's three plants on the Kootenay river.

The city of Kamloops carried out considerable work in connection with its plant on the Barriere river. A dam at the outlet of East Barriere lake was built to impound some 15,000 acre-feet of storage and other work was done on the flume and forebay structure which will permit of an increase of 1,000 horse-power in plant capacity at a later date.

Other active construction in British Columbia included a small development of 80 horse-power by the Nicola Lake Stock Farms Limited at the outlet of Nicola lake for pumping water to irrigate bench lands along the Nicola river, a diversion from Handy creek into Cass creek by the Wallace Fisheries to benefit their power development during the summer months and a tunnel under construction by the British Columbia Pulp and Paper Company to tap its Henrietta Lake reservoir at a deeper level thus doubling the available storage of 100 million cubic feet for the benefit of the Wood-fibre power development.

Among hydro-electric investigations carried on during the year, the following may be mentioned: The Canadian Crown Willamette Co., Ltd., made extensive investigations in connection with a proposed development of 70,000 horse-power on the Campbell river to supply power to a proposed pulp and paper mill at tide water near the mouth of the same river. The Canadian Forest Products Ltd., have increased their activities in connection with the investigation of a power project of 60,000 horse-power on the Nimpkish river for the supply of a proposed pulp and paper mill at Beaver Cove.

The West-Canadian Hydro-Electric Corporation recently made an agreement to supply the city of Vernon with power from the Shuswap river for which surveys are being made and plans prepared. On Watson creek the Marmon Mine Ltd., of Big Bar Post Office has made surveys and prepared plans with the object of installing a 1,000-horse-power hydro-electric plant during 1928, the power to be used for mining purposes.

Alberta.—While no additions were made during the year to the total water-power installation in Alberta, the Calgary Power Company carried forward a considerable program of extensions to its electric transmission system, receiving power from its two developments on the Bow river near Seebe. Lines which had been built during 1926 to High River and Blackie were extended south to serve such towns as Nanton, Stavely, Claresholm, Granum, Vulcan, Champion, Carmangay, Coaldale, Taber and Magrath. Arrangements have also been made with the city of Lethbridge to include that city in the system.

In connection with the supply of power in the Crows Nest coal mining district of Alberta and British Columbia it is interesting to record the construction of a 13,000-kv.a. steam power station at Sentinel, Alberta, by the East Kootenay Power Company, Ltd. This station is auxiliary to the company's 2 hydro-electric stations on the Bull and Elk rivers in British Columbia.

Saskatchewan.—While no hydro-electric construction took place in Saskatchewan during 1927 a matter of very considerable import to the province was the appointment, by the Government of Saskatchewan, of a commission to inquire into and report upon the economic practicability of generating power at central fuel-power plants and at water-power sites and of distributing the same throughout the province. This commission under the chairmanship of Mr. L. A. Thornton of Regina, carried on a very active program of investigation in all parts of the province throughout the year.

Manitoba.—In Manitoba the total installation in the province was increased 28,000 horse-power by the addition of unit number four in the Great Falls plant of the Manitoba Power Company on the Winnipeg river. The company also completed the construction of a new transmission line 70 miles in length from Great Falls to Winnipeg and a second line 42 miles in length from Great Falls to the central Manitoba Mines. The power station superstructure at Great Falls was extended to include units 4, 5 and 6 and the company has announced its intention of proceeding with the installation of the final units 5 and 6, which are to be of 40,000 horse-power each.

The city of Winnipeg made provision for the addition of flashboards to its dam at Pointe du Bois on the Winnipeg river and in an effort to improve tail-water conditions at the power station awarded a contract for the excavation of a rock cut to increase the discharge capacity of the river at Eight Foot Falls. The city is also reported to be considering proceeding with the development of Slave falls on the Winnipeg river with the view of having the initial development completed by 1931 in order to take care of the expected growth of load by that time.

During the year the Manitoba Power Commission built 140 miles of wood pole transmission lines. These lines are extensions to the commission's existing transmission system and are to supply the villages of Altamont, Somerset, Swan Lake, Cardinal, Notre Dame de Lourdes, Rathwell, Treherne, Holland, Cypress River, Glenboro, Darlingford, Manitou, La Riviere, Pilot Mound, Crystal City, and Graham Siding.

Of projected developments in Manitoba, one of the greatest importance to the future development of the northern part of the province is proposed at Whitemud falls on the Nelson river. This is in connection with the development of the Flin Flon mine about 70 miles to the north west of The Pas which has recently been acquired by the Whitney mining interests. An initial development of 30,000 to 40,000 horse-power is proposed and a transmission line of about 170 miles will be required to carry the power from Whitemud falls to the mine.

Ontario.—The increase of 26,320 horse-power to the total water-power installation in Ontario was accounted for chiefly by the Sturgeon Falls and Moose Lake developments of the Ontario and Minnesota Power Company on the Seine river in the western part of the province. The Sturgeon Falls plant, situated 58 miles east of Fort Frances has an installation of 10,000 horse-power while the Moose Lake development 104 miles from Fort Frances has 14,420 horse-power. A transmission line delivers electric energy from these two plants to the pulp and paper mills at Fort Frances. A third plant situated at Calm Lake on the same river between the two already mentioned is nearing completion and is expected to go into operation early in 1928. This development will have an installed capacity of 13,200 horse-power.

The other installations added during the year include 1,500 horse-power by the Gananoque Electric Light and Water Supply Company at its Kingston Mills plant on the Cataraqui river near Kingston, a development of 325 horse-power by the town of Smiths Falls on the Rideau river in connection with the municipal water works and a unit of 75 horse-power added to the development of the town of Streetsville on the Credit river.

Of work under construction the transmission line which the Ontario Hydro-Electric Power Commission is building to carry power from Fitzroy Harbour on the Ottawa river to Toronto and southwestern Ontario is of outstanding interest. This line which will be more than 200 miles in length will operate at 220,000 volts, the highest voltage of any line in the Dominion, and will deliver the 260,000 horse-power which the commission has contracted to take from the Gatineau Power Company at the Ontario boundary. The commission is carrying out the construction work by its own organization and expects to have the line completed and ready for operation by September 1928.

Additional to the work on this transmission line the commission actively carried forward the construction of a new 54,000-horsepower development at Alexander Landing on the Nipigon river. This plant is expected to be completed in 1929 and the power will go to the Thunder Bay system to serve Port Arthur, Fort William and industries in that district.

The commission made a number of investigations of water-power projects during the year among which were field studies of sites on the English river in the western part of the province and on the Mississagi and Montreal rivers in connection with a proposed supply to the city of Sault Ste. Marie and district.

On the Mattagami river in northern Ontario the Spruce Falls Company made rapid progress on its development at Smoky Falls. The initial intallation of 56,250-horsepower is expected to be ready for operation by August 1928 when power will be transmitted to the company's pulp and paper mills at Kapuskasing.

The International Nickel Company of Canada, Limited, is initiating the development of 28,200-horsepower at its Big Eddy dam on the Spanish river which was built several years ago for the purpose of creating storage. Actual construction work will start about March 1928 and it is expected to have the plant in operation some time in the spring of 1929.

On the Montreal river at Indian Chutes the Great Northern Power Corporation replaced a rockfill dam by a concrete dam in connection with its power development and on the same river at High falls a concrete dam was built to replace a timber structure utilized to impound storage.

Quebec.—New plants and extensions to existing plants, actually placed in operation during 1927, added 149,280 horse-power to Quebec's hydro-electric installation; this additional capacity being mainly found in the two new plants on the Gatineau river.

These new plants of the Gatineau Power Company may be considered as the outstanding achievement of the year. The Chelsea development commenced operation in January with a 34,000-horse power unit which was in place in December, 1926, and had been credited to the installation for that year. Two further units of similar capacity were brought into operation later in the year bringing the total to 102,000 horse-power. Provision remains for two further units which will give the plant a total capacity of 170,000 horse-power. At the Farmers Rapids development three 24,000-horsepower units were brought into operation totalling 72,000 horse-power, while as at the Chelsea plant, provision has been made for the addition of two further units which will give the plant an ultimate capacity of 120,000 horse-power. The power generated at these two plants is at present supplying the needs of the Canadian International Paper Company's mill at Gatineau where four 125 ton per day paper machines were placed in operation during the year.

About twenty-seven miles above Chelsea the Gatineau Power Company vigorously carried forward the construction of a third plant at Paugan Falls. Here six units each of 34,000-horsepower capacity are being installed and are expected to be ready for operation in September, 1928. This power is designed to supply in part the contract the company has with the Ontario Hydro-Electric Power Commission and a transmission line is under construction from Paugan Falls to the Ottawa river at Fitzroy Harbor where it will connect with the line the commission is constructing and which has been mentioned in the Ontario section of this review.

A fourth plant at Nigger rapids on the same river, a short distance below Maniwaki, is contemplated for future development by the company when load conditions warrant.

For the benefit of all these plants the Mercier dam, creating a very extensive storage reservoir of 95 billion cubic feet on the Gatineau was also completed and filled early in the year under the direction of the Quebec Streams Commission.

During the year the Gatineau Power Company also acquired the plants and systems of the Ottawa-Montreal Power Company and of the Quebec Southern Power Corporation, completing the enlargement of the latter's Rawdon plant on the Oureau river from 300 to 2,150 horse-power. The company also has in view a number of moderate sized developments north of Montreal and in western Quebec such as on the Petite Nation and North rivers.

The Shawinigan Water and Power Company placed in operation a plant of 4,000 horse-power at St. Alban on the Ste. Anne-de-la-Perade river replacing a former plant damaged by floods. This company has also started work in connection with the installation of an additional 40,000-horsepower unit in its number two plant at Shawinigan Falls.

The same company carried out a most notable achievement in the completion of a 165,000-volt transmission line, 136 miles in length through an almost entirely uninhabited territory to bring power from the Isle Maligne station of the Duke-Price Power Company on the Saguenay river to the city of Quebec. This line, which at present is the highest voltage line in operation in Canada, is designed to carry over 100,000 horse-power for the supply of large pulp and paper mills recently erected in the vicinity of Quebec.

On the Saguenay river, at Chute-a-Caron the Alcoa Power Company is actively pressing the development of a plant which will have an ultimate capacity of 800,000 horse-power while the Duke-Price Power Company has still two units to install in its Isle Maligne station to bring it to its ultimate designed capacity of 540,000 horse-power. One of these units will be installed during 1928.

Other installations placed in operation during 1927 included the addition of a 2,000-horsepower unit at the Pont Rouge plant of the Donnacona Paper Company on the Jacques Cartier river and the completion of a 2,000-horsepower hydro-electric plant by the town of Coaticook on the river of the same name replacing smaller installations aggregating 570 horse-power.

Among projects or extensions under active construction may be mentioned a 65,000-horsepower development by the Montreal Island Power Company on des Prairies river near Montreal; the addition of two 10,000-horsepower units to the Canada Northern Power Company's plant on Quinze river, to be ready July, 1928; and a 300-horsepower plant by the Cie d'Enterprises Publiques near Riviere a Piere, Quebec, on the river of the same name. It may also be noted that construction on the Ontario Paper Company's 40,000-horsepower plant near the mouth of the Outardes river was well advanced during the first part of the year. Contracts have been let by the city of Sherbrooke for a new development of 5,800 horse-power at Westbury rapid on the St. Francois river and the Ottawa River Power Company has authorized the addition of a 25,000-horsepower unit to its development near Bryson on the Ottawa river. Among other developments being considered for the near future are a 2,000-horsepower plant on La Sarre river in Abitibi county and series of four developments with heads ranging from 92 to 125 feet on the Etchemin river, near Levis.

The Quebec Streams Commission, in addition to completing and placing in operation the already mentioned Mercier reservoir on the Gatineau river, continued to enhance and encourage water-power development in various sections of the province through similar beneficial work in connection with its extensive storage reservoirs at Gouin dam and Manouan on the St. Maurice river; Allard dam and Aylmer lake on the St. Francois; Taschereau dam at Kenogami lake and others on Ste. Anne de Beaupre, Metis and North rivers. During the past year the commission also pursued work and studies in connection with power development on the Ottawa river; water regulation of the northeast branch Yamaska river; profiles of Richelieu and Etchemin rivers; flood protection works on river du Bras at Baie-St. Paul; and further storage reservoir studies on Ste. Richelieu, Etchemin, Du Sud, Jeannette and Peribonka rivers.

New Brunswick.—While no water-power installation was actually added to New Brunswick's total in 1927 work of magnitude was carried forward at Grand Falls on the St. John river and numerous projects received intensive investigation.

On the St. John river at Grand Falls the Saint John River Power Company, a subsidiary of the Canadian International Paper Company, actively pressed the construction of its development which is designed to have a capacity of 80,000 horse-power in four units of 20,000 horse-power each operating under a head of

130 feet. At the end of the year the dam, power station, tunnel, intake and penstocks were practically completed. It is expected one unit will be in operation by July 1928, after which the others will follow as required.

The output will be used principally in newsprint mills to be erected by the New Brunswick International Paper Company and the pulp and paper mills of the Fraser Companies Limited. The latter company has completed surveys for a transmission line to carry about 5,000 horse-power from Grand Falls to Edmunston.

During the year the New Brunswick Electric Power Commission made extensions to the transmission lines in its Musquash system totalling 65 miles. These extensions included such municipalities as Lakeside, Nauwigewauk, Dickson's Neck, Pointe du Chene, Brule, Penobsquis, Colpitts, Barachois, Newton Heights and Elgin.

The Bathurst Company Limited after a thorough investigation of the Nipisiguit river in 1926 established that the total power available from the five sites on the river, including the Great Falls site now developed, was in the vicinity of 40,000 continuous horse-power. Of the undeveloped sites, the company has now under active consideration the development of the one known as Rough Waters near the mouth of the river where an installation of from 8,000 to 10,000 horse-power may be made. The power would be used principally in the company's paper mill at Bathurst.

Investigations were also made of power possibilities on the St. John river below Grand Falls. The New Brunswick Electric Power Commission made an extensive investigation of the forty-mile reach between Woodstock and Hawkshaw where a total head of about 60 feet exists which, with a regulated flow of 5,000 cubic feet per second would yield 30,000 continuous horse-power. Other sites of about the same or somewhat less capacity are situated at Morrells Siding and Beechwood between Woodstock and Grand Falls and are now under investigation by the Saint John River Power Company.

Two tidal power projects are under investigation on the bay of Fundy, the first at Passamaquoddy bay by the Dexter P. Cooper Company and the second at the estuaries of the Petitcodiac and Memramcook rivers by the Petitcodiac Tidal Power Company.

Nova Scotia.—The outstanding hydro-electric construction work in Nova Scotia during 1927 was the construction of the Sandy Lake development of the St. Margaret Bay system supplementing the Tidewater and Mill Lake developments already in operation. Two units of 2,500 horse-power each were installed in the Sandy Lake plant and the power generated will be carried over the commission's transmission lines to Halifax.

The only other installation during the year was an addition of 315 horse-power to the plant of Bridgetown Electric Light Company on Bloody brook together with other improvements and additions to the company's transmission lines involving an extension of 21 miles from Round Hill to Deep Brook. It is planned to further extend the line to Bear river to connect with the company's small hydro-plant on the West Branch of that river.

The Avon River Power Company has under construction a second hydro-electric plant on the Avon river at Avon River falls. An installation of 4,350 horse-power is beig made and is expected to be complete about midsummer of 1928. The transmission lines of the company were also extended during the year to Walton on the Minas Basin shore between Windsor and Truro.

The town of Middleton has storage dams under construction at the Curl Hole Reservior on the Nictaux river to provide the additional regulation demanded by increases in load at the municipal hydro-electric plant at Nictaux

Falls. The Middleton plant recently added the town of Kingston to its customers and the Kingston Electric Light Commissioners constructed a transmission line 10 miles in length from Kingston to Nictaux falls.

Work is also under way in connection with the diversion of water from the west branch of the Avon river into the Gaspereau river for the benefit of the White Rock hydro-electric development of the Gaspereau River Light, Heat and Power Company on that river.

There are possibilities of large increases in power demand in the Sheet Harbour and Pictou County districts which may soon require that the East River Sheet Harbour be developed to its fullest capacity by means of a generating station at Marshall Falls and dams at all storage sites now undeveloped. A further possible development is at lake Ainslie in Cape Breton where investigations of the Nova Scotia Power Commission have indicated about 3,000 continuous horse-power to be available. This power would be used to supply the district centred on Sydney.

Other recent investigations of the Nova Scotia Power Commission included the Liverpool river where more than 30,000 continuous horse-power may be secured and the Medway river with over 20,000 continuous horse-power.

The commission is also securing complete information with regard to a proposed tidal power project at Amherst point on the Bay of Fundy where it has been estimated 20,000 continuous horse-power could be secured.

Prince Edward Island.—In Prince Edward island the Montague Electric Company Limited completed a development on the south branch of the Montague river about two miles above its mouth and about three miles from the town of Montague. The installation consists of a pair of horizontal twin turbines with a combined capacity of 160 horse-power under a head of 30 feet.

UTILIZATION OF DEVELOPED WATER-POWER

Canada's total installation of 4,777,921 horse-power is divided in table 2 as between the three main headings of central electric stations, pulp and paper mills and other industries—

Three million nine hundred and four thousand six hundred and seventy-eight horse-power or 81·7 per cent of the total is installed in central electric stations for general distribution for domestic, municipal and commercial lighting and power purposes.

Five hundred and twenty-eight thousand seven hundred and thirty-one or 11·1 per cent is installed in the power plants of pulp and paper mills. In addition the pulp and paper industry purchases some 774,000 horse-power from the hydro-electric central stations.

Three hundred and forty-four thousand five hundred and twelve horse-power or 7·2 per cent of the total is installed for other industrial use such as driving saw, grist and grinding mills, machine shops, pumping plants, electric reduction plants, etc.

Column 7 of table 2 shows the hydraulic installation per 1,000 of population for Canada and each of the provinces. The average for Canada has now reached the high figure of 502 horse-power per 1,000 of population and four of the provinces exceed this average figure, viz. Yukon and Northwest Territories, British Columbia, Quebec and Ontario. While the Yukon and Northwest Territories have the largest per capita installation, viz. 1,100 horse-power per 1,000 of population, this figure is not actually comparable to those of the other provinces

in that they are the product of heavy power demands for mining together with a small population. British Columbia with a considerable portion of its installation developed for the pulp and paper and mining industries, with their heavy power demands, has an installation of 823 horse-power per 1,000 of population, while Quebec is next in order with 793 horse-power, Ontario's average installation, affected by the retail nature of its central electric station distribution, is 570 horse-power per 1,000 of population. Manitoba ranks next in order with 394 horse-power.

Water-power in the Central Electric Station Industry

As indicated in Table 2 almost 82 per cent of Canada's total hydraulic installation is in central electric stations. This percentage has risen steadily and there is every indication that the trend will continue. The extensive economic radius of modern electric transmission combined with the fortunate location of water power in relation to centres of industry removed from supplies of native fuel has led to the development of enormous amounts of hydraulic power for use in manufacturing in established centres where labour is plentiful and of a permanent character, with shipping and distributing facilities readily at hand. Such centres with their varied manufacturing needs and processes, electric railways to be operated, buildings to be lighted and heated, together with the various municipal demands for street light, water pumping and similar services provide a diversity of load which forms an ideal market for the product of the central stations. The special adaptation of water power to central electric station operations is further emphasized by the fact that for several years past the electrical output of the hydraulically driven central stations has been in excess of 98 per cent of the total electricity distributed in Canada for public use.

Throughout the Dominion at the present time there are 308 hydro-electric central stations with a total turbine installation of 3,904,678 horse-power of which 218, with a combined capacity of 2,645,474 horse-power, are owned by commercial organizations and 90 totalling 1,209,204 horse-power by municipal or other public organizations (see table 3).

Water-power in the Pulp and Paper Industry

Pulp and paper manufacturing is one of the foremost Canadian industries with a future of almost unlimited prosperity, the result of two natural advantages of almost equal moment, namely, an abundant supply of growing pulpwood and low priced, easily accessible motive power in large quantities. The importance of low priced power lies in the fact that it takes practically 100 horse-power to produce one ton of newsprint per day, while any surplus of avaliable electric energy can be readily converted into steam, for heating or process cooking, in electric steam generators. It is not surprising, therefore, that motive power used in this industry is almost altogether restricted to hydraulic energy and that Canada's premier advantage and position in the pulp and paper field rests on adequate and abundant water power well distributed among extensive forest reserves.

Table 4 presents an analysis of the use of hydraulic power in the pulp and paper industry of Canada and shows that there is a total installation of 528,731 horse-power in connection with the mills themselves while the additional hydro-electric energy purchased from central electric stations is estimated at over 774,000 horse-power, giving a total utilization of hydro-power of 1,302,972 horse-power.

The electric drive is an important consideration in the industry, providing the uniform speed which assures a high quality product and permitting the establishment of the mill at the place most suitable from the viewpoint of operation and shipment of product. It also permits the centralized operation of large mills receiving power from several hydro-electric sources. Column 2 of Table 4 shows that 242,720 horse-power or almost half of the total hydraulic installation of the pulp and paper mills is connected to electric generators; combining this figure with the total of column 5 shows that hydraulic turbines of an estimated total of 1,016,961 horse-power are connected to electric generators to supply the demands of the industry.

PAST AND FUTURE GROWTH IN UTILIZATION OF WATER-POWER

The growth of water-power development is very largely the outcome of the solving of the problem of the long distance transmission of electricity during the last decade of the nineteenth century by the end of which approximately 170,000 horse-power had been installed in Canada.

With the ever increasing use of electricity the installation had grown to 975,000 horse-power by the end of 1910 and 1,946,000 horse-power at the close of 1914. During the war years and period of post war depression growth was retarded and the figure had increased to 2,508,000 horse-power at the end of 1920. Following this, however, an intensive period of development set n with the result that by the end of 1927 the total installation has grown to the impressive figure of 4,777,921 horse-power.

With new uses for electricity constantly developing there is every reason for believing that hydraulic development will show constantly accelerating growth over past figures. Chief among these new uses may be mentioned railway electrification, the application of electric-heat to manufacturing processes, the more extensive use of electric boilers for process steam, commercial and domestic electric refrigeration and other uses constantly appearing. The highest authorities in the electrical field are agreed that the power market has not yet shown any signs of saturation.

CAPITAL INVESTED IN WATER-POWER

The stability of Canadian water-power investments is a subject on which there is much information available from reliable sources. The range of prices of bonds and stocks of leading hydro-electric companies and the dividends paid during the past ten or fifteen years, as shown by the Montreal and Toronto Stock Exchange records, affords convincing evidence of the stability of the capital and the regularity of the interest.

The capital invested in the water-power industry in Canada is estimated to be $875,000,000 or more than that for any other single manufacturing industry. The corresponding figure in 1910 was $121,000,000 so that the increase in seventeen years is over 600 per cent. This total includes the cost of the primary and auxiliary power plants, transmission and distribution systems with land, machinery and equipment. Applied to the existing installation it amounts to an average of $183 per horse-power and in view of the steady earning power shown by the industry even in times of industrial difficulties and depression, it would appear that this capitalization is reasonable and one which the industry is well able to carry.

Water-power development in Canada is no longer speculative but has become a highly specialized process, recognized as such by leading financial houses and by individual investors all over the world and particularly on this

continent. That new capital is readily available for enterprises of a promising character, is shown by the remarkable development carried out within the past three years involving expenditures upwards of $180,000,000.

The openings for further investment in Canadian hydro-electric enterprises are likely to be numerous; the resources of raw material are exceptionally varied and abundant; labour conditions are relatively stable; the total manufactures and the proportion of manufactures exported show rapid and sustained increase while for legitimate power projects governmental co-operation is sympathetic and constructive.

COAL EQUIVALENT OF DEVELOPED WATER-POWER

The development of water-power in Canada has had a direct and very great effect in reducing the consumption of coal and while it is very difficult to assign a precise figure of the coal equivalent of developed water-power as the matter is comparative only and assumptions must necessarily be made dependent upon the conditions under which the power is developed, however, taking into account all present conditions surrounding water-power development in Canada and comparing them with somewhat similar conditions of fuel development elsewhere it is reasonable to state that a saving of coal of six tons per annum is capable of being effected by each installed horse-power. This means that the total present water-power installation of 4,778,000 horsepower is capable of effecting a saving of about 28,500,000 tons of coal per annum. With the marked economies that are continually taking place in coal consumption in fuel-power stations it will be necessary to adjust from time to time the coal equivalent of developed water-power, but under existing conditions the figure of 28,500,000 tons is not unreasonable.

Table I.—Available and Developed Water-power in Canada, January 1, 1928

Province	Available 24-hour power at 80 per cent efficiency		Turbine installation h.-p.
	At Ordinary min. flow h.-p.	At Ordinary 6 months flow h.-p.	
1	2	3	4
British Columbia	1,931,000	5,103,500	473,142
Alberta	390,000	1,049,500	34,107
Saskatchewan	542,000	1,082,000	35
Manitoba	3,309,000	5,344,500	255,125
Ontario	5,330,000	6,940,000	1,816,908
Quebec	8,459,000	13,064,000	2,064,723
New Brunswick	87,000	120,800	47,231
Nova Scotia	20,800	128,300	71,017
Prince Edward Island	3,000	5,300	2,434
Yukon and Northwest Territories	125,200	275,300	13,199
Canada	20,197,000	33,113,200	4,777,921

The figures listed in Columns 2 and 3 in the above table represent 24-hour power and are based upon rapids, falls and power sites of which the actual existent drop or the head possible of concentration, is definitely known or at least well established. Many rapids and falls of greater or lesser power capacity are scattered on rivers and streams from coast to coast which are not as yet

recorded, and which will only become available for tabulation as more detailed survey work is undertaken and completed. This is particularly true in the more unexplored northern districts. Nor is any consideration given to the power concentrations which are feasible on rivers and streams of gradual gradient, where economic heads may be created by the construction of power dams, excepting only at such points as definite studies have been carried out and the results made matters of record.

The figures in Column 4 represent the actual water wheels installed throughout the Dominion. These figures should not be placed in direct comparison with the available power figures in Columns 2 and 3 for the purpose of deducting therefrom the percentage of the available water-power resources developed to date. The actual water wheel installation throughout the Dominion averages 30 per cent greater than the corresponding maximum available power figures calculated as in Column 3. The figures quoted above, therefore, indicate that the *at present recorded water-power resources* of the Dominion will permit of a turbine installation of about 43,000,000 horse-power. In other words, the present turbine installation represents only *a little more than 11 per cent* of the present recorded water-power resources.

The above figures may be said to represent the *minimum water-power possibilities* of the Dominion.

As illustrative of this the detailed analyses which have been made of the water-power resources of the provinces of New Brunswick and Nova Scotia have disclosed most advantageous reservoir facilities for regulating stream flow and it is estimated that the two provinces possess within their respective borders 200,000 and 300,000 commercial horse-power. These figures provide for a diversity factor between installed power and consumers' demands.

CENSUS OF THE CENTRAL ELECTRIC STATION INDUSTRY

The development of the central electric station industry in Canada has been based almost solely upon the utilization of hydraulic power, the converse proposition that hydraulic development has been largely due to the progress of the central electric stations also holding good.

The close interconnection of these two outstanding factors in the development of Canada's natural resources and in the high standard of life of her citizens is at once made evident when it is stated that 82 per cent of the total hydraulic installation is in central electric stations while for several years past the electrical output of these hydraulically driven central stations has been in excess of 98 per cent of the total electricity distributed in Canada for public use.

The foregoing facts premise the importance to this Service of the frequent periodic revision of all basic data relating to the central electric station industry and this revision is accomplished through the medium of an annual census inaugurated by the Dominion Water Power and Reclamation Service and conducted in co-operation with the Dominion Bureau of Statistics of the Department of Trade and Commerce.

The general statistics of this census are made available through annual reports issued by the Dominion Bureau of Statistics while at longer intervals a Directory of Central Electric Stations presenting a comprehensive review of the scope and character of all organizations, commercial or municipal, distributing electricity for sale is published. The various aspects of personnel; capital invested; generating, transmitting and distributing equipment used; power

generated, purchased and sold; blocks of power available for sale, rates and transportation facilities are presented in a form that renders the Directory a highly valuable reference to the extensive financial and technical interests concerned with the industry.

The general statistical review of the tenth annual census, that for the calendar year 1926, has just appeared in preliminary form and will be followed shortly by the final report while the third issue of the Directory descriptive of conditions obtaining May 1, 1928, will be issued shortly.

DOMINION HYDROMETRIC SURVEY

The Dominion Hydrometric Survey embraces stream measurement work throughout Canada. The records are brought together in one central agency, which attends to the compilation and dissemination of stream-flow data, and the survey operates efficiently both as regards office administration and field operations.

In the Prairie Provinces the work is the direct responsibility of the Dominion Government and in the other provinces the survey is carried on by the Dominion Government under co-operative agreements with the provinces concerned. The Dominion is divided into major drainage divisions, which, together with the district office or offices in charge, are as follows: Pacific drainage, Vancouver; Arctic and Western Hudson Bay drainage, Calgary and Winnipeg; St. Lawrence and Southern Hudson Bay drainage, Ottawa and Montreal; Atlantic drainage, Halifax.

The uses to which the records are put are primarily in connection with water-power development and irrigation projects, and not a small part of the credit for the rapid strides which have been made in the hydro-electric field is due to the detailed and extensive records of the regimen of the numerous lakes and rivers of the country which have been made available by the Dominion Hydrometric Survey, assisted by the voluntary co-operation of the provinces, of private corporations and of numerous individuals.

Run-off Conditions in Canada.—As set forth in detail in the Annual Reports of the district chief engineers, the average run-off for the year has been generally above normal throughout the Dominion.

In the Pacific drainage typical stations showed a range in run-off for the year from 104 per cent of the long-term mean in Capilano creek in the coast region to 148 per cent of the long-term mean in the Kootenay river at Wardner.

In the Arctic and Western Hudson Bay drainage typical stations showed a range in run-off for the year from 106 per cent of the long-term mean on the Peace river in northern Alberta to 353 per cent of the long-term mean in Moosejaw creek in Saskatchewan. In southeastern Manitoba and in Western Ontario, especially in the Winnipeg river watershed, maximum discharges for the period of record were experienced.

In the St. Lawrence and southern Hudson Bay drainage typical stations showed a range in run-off for the year from 81 per cent of the long-term mean in the north Magnatawan river in the North Bay district to 168 per cent of the long-term mean in the Missinaibi river in northern Ontario.

In the Atlantic drainage typical stations showed a range in run-off for the year from 103 per cent of the long-term mean in the Medway river in Nova Scotia, to 127 per cent of the long-term mean in the Miramichi river in New Brunswick.

FIELD REPORTS

DISTRICT OF BRITISH COLUMBIA

C. E. Webb, District Chief Engineer

Throughout the fiscal year ended March 31, 1928, systematic hydrometric investigatory operations have been continued in the British Columbia district by the Dominion Water Power and Reclamation Service in accordance with the terms of the co-operative agreement existing between the Department of the Interior and the Provincial Government of British Columbia.

Organization

The district head office is located at 739 Hastings Street West, Vancouver, from whence field operations are directed while a branch office is maintained at Kamloops to facilitate investigations in the interior of British Columbia. This organization's primary object is to acquire and tabulate stream-flow data to be used in connection with the study of irrigation, reclamation, domestic water supply and power developments. The services of this organization are also used for the supervision and prosecution of engineering investigations and works on behalf of other government departments, especially in connection with hydraulic problems.

A great deal of work is done for the Department of Indian Affairs in British Columbia, both in connection with the adjustment of Indian water-rights and the installation of irrigation systems, domestic water supply, sewage disposal, drainage, river bank protection and electric lighting plants on Indian reserves and villages. Three engineering parties have been maintained almost constantly in the field during the past year, while other related matters have been handled in the head office in Vancouver.

Co-Operation

In accordance with the terms of the co-operative agreement with the British Columbia Provincial Government, all hydrometric investigations are made by this Service and, to fully comply with this agreement, stream-flow data are being supplied constantly to the Comptroller of Water Rights at Victoria and his District Water Rights engineers throughout the province. A complete record of all stream-flow data is annually supplied to the Provincial Water Rights Branch.

In co-operation with the Water Resources Branch of the United States Geological Survey, gauging stations have been maintained on the Columbia, Pend d'Ireille (Clark Fork) and Okanagan rivers, which are important international waters.

Hydrometric investigations of Brunette river at the outlet of Burnaby lake, and the new drainage canal through which Still creek enters the lake, have been continued in the interests of the Vancouver and Districts Joint Sewerage and Drainage Board.

In the Bridge River district hydrometric investigations have been continued in co-operation with the British Columbia Electric Railway, six gauging stations in all having been maintained and miscellaneous records obtained on eight other important streams in the area.

Close co-operation has also been maintained with the city of Vancouver in the continuance of special hydrometric investigations to collect requisite data concerning economic power sites within reasonable transmission distance of the city.

This Service has maintained close relations with the Greater Vancouver water district in its investigations for domestic water supply for Greater Vancouver area.

In connection with hydro-electric power projects, this Service has co-operated during the year with a large number of power companies, including: the Canadian Crown Willamette Co. Ltd., on the Campbell river; the Vancouver Kraft Mills Ltd., on Rainy river; the Canadian Forest Products Ltd., on the Nimpkish river and Pacific Mills Ltd., on the Nascall and Dean rivers.

Close co-operation was maintained with the Dominion Lands Administration during the year. Investigations are made by this Service and reports and plans submitted when required covering applications to purchase lands in the British Columbia Railway Belt and in connection with any other problems of an engineering nature which confront this administration from time to time. In co-operation with the Ordnance Lands Branch this Service supervised a project in the vicinity of New Westminster for the draining of certain of their lands.

Hydraulic engineering assistance of this Service was continued during the year at the request of the Department of Marine and Fisheries, in the prosecution of hydraulic studies of the Fraser river at Hell's Gate reach where it has been asserted an impediment exists preventing the satisfactory migration of salmon. The construction of a small scale model of the Hell's Gate reach was authorized and built. Experiments of a very interesting and instructive nature were carried out with this model in the hydraulic laboratory of the University of British Columbia and a report dealing with the result of these experiments has been prepared.

Hydraulic investigations have been carried out on the Kootenay river in connection with international problems arising on the river.

Close co-operation with the Department of Indian Affairs has been continued. A large variety of projects requiring engineering assistance or advice, dealing with water matters, have been dealt with.

Fifteen conditional licences were issued to the Department of Indian Affairs for the diversion and storage of water for use on Indian reserves during the year. As all works required under conditional licences granted by the provincial authorities will have to be carried to completion within the time specified under each licence, close engineering supervision will be required in order that the Department of Indian Affairs may reap the full benefit of water allotted to them.

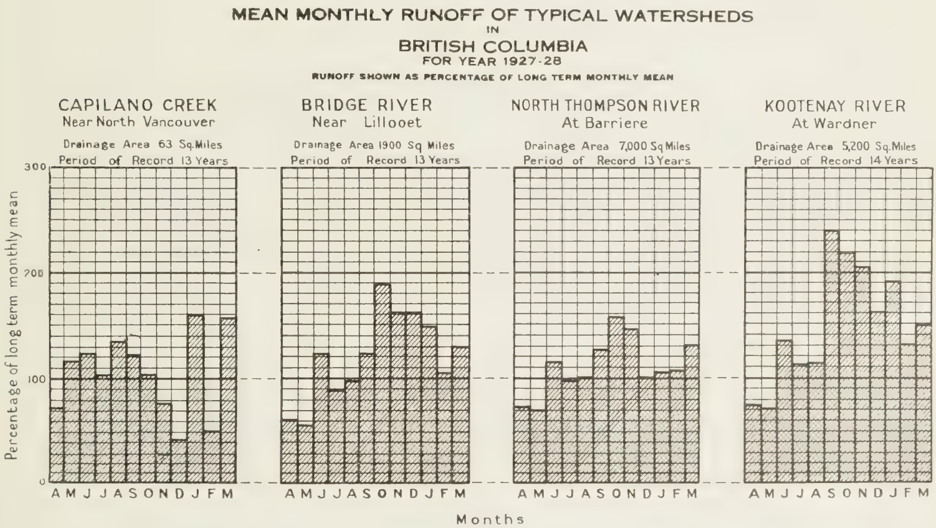
Hydrometric Survey

Two hundred and fifty-two gauging stations were maintained for the whole or part of year ended March 31, 1928, on rivers and tributaries in the following main watersheds: Columbia, Fraser, Kettle, Kootenay, North Thompson, Okanagan, Pacific Coast (Mainland), Similkameen, South Thompson, Thompson, Lillooet and Vancouver Island. Many of these stations were maintained for more than one purpose, 84 were maintained for power, 160 for irrigation, 21 for drainage and reclamation, 12 for domestic water supply, 29 for flood warning purposes, 22 for navigation, 21 in connection with international problems and 8 for statistical purposes. There were 40 new stations established and 1 discontinued. Of the new stations 34 were established at the request of the Provincial Water Rights Branch for water-power investigations and irrigation problems throughout the province, 1 was established to meet the needs of the Greater Vancouver water district, 2 for the Hell's Gate problem, and 3 in connection with flood warnings on the Fraser river.

During the past year the temperature throughout the province has been above normal in the coast area but below normal in the interior due to an exceptionally cold November and December. Precipitation likewise has been below normal in the coastal area and above normal in the interior where heavy rains and snows occurred in the early winter of 1927-28.

The run-off during the year was above normal throughout the province, due in part to the heavy snowfall of the winter of 1926-27 which appeared as run-off during the early summer of 1927. The run-off each month as a percentage of the long-term monthly mean is shown on Plate I for the following stations typical of the Pacific Drainage: Capilano creek near Vancouver, Bridge river near Lillooet, North Thompson river at Barriere and the Kootenay river at Wardner.

PLATE 1



In the coast area, as typified by Capilano creek, which has a drainage area of 64 square miles, low precipitation and run-off above normal were recorded, the former being 94 per cent of the long-term mean, and the latter 104 per cent. Flood run-off reached a maximum daily discharge of 103 second-feet per square mile in October, as compared with 264 second-feet in October, 1921. The low run-off which occurred in August was at the rate of 2·5 second-feet per square mile, as compared with 0·47 second-foot per square mile in October, 1925, and August, 1926, the minimum in the past thirteen years.

In the Central Fraser basin, as typified by Bridge river, which has a drainage area of 1,900 square miles, precipitation was below and run-off was above average, the former being 79 per cent of the long-term mean and the latter 120 per cent. The flood run-off reached a maximum daily mean discharge of 7·89 second-feet per square mile in June, compared with 13·7 second-feet in June, 1913. The low run-off which occurred in April, 1927 and February, 1928, was at the rate of 0·25 second-foot per square mile, as compared with the previous low in the thirteen years of record of 0·09 second-foot in November, 1925.

In the North Thompson River basin, as typified by the North Thompson river at Barriere, which has a drainage area of 7,000 square miles, the yearly precipitation and run-off were both above normal, the former being 166 per cent of the long-term mean while the latter was 110 per cent of the long-term mean. The flood run-off reached a maximum daily mean discharge of 8·01 second-feet per square mile in June, compared with 11·16 second-feet in June, 1921. The

low run-off, which occurred in February, was at the rate of 0·31 second-foot per square mile, as compared with 0·214 second-foot in February and March, 1919, the minimum discharge recorded during the past thirteen years.

In the Upper Kootenay basin, as typified by the Kootenay river at Wardner, which has a drainage area of 5,200 square miles, the yearly precipitation and run-off were above normal, the former being 115 per cent of the long-term mean, while the latter was 148 per cent of the long-term mean. The flood run-off reached a maximum daily mean discharge of 9·23 second-feet per square mile in June, as compared with 13·0 second-feet in June, 1916. The low run-off, which occurred in April, was at the rate of 0·25 second-foot per square mile, as compared with 0·12 second-foot in January, 1914, the minimum discharge previously recorded during the past fourteen years.

Special Investigations

Co-operative hydrometric investigations with the city of Vancouver, the Greater Vancouver water district, and other investigations in co-operation with different power companies throughout the province, have already been referred to. Intensive study of the flow of Capilano and Seymour creek drainages is continuing in anticipation of furture development of the water system to supply the Greater Vancouver water district.

In co-operation with the power and reclamation projects on the Kootenay river and further possible development of these international waters, intensive study of water supply and hydraulic factors of Kootenay lake and river below Bonner's Ferry, Idaho, were continued throughout the fiscal year.

The winter of 1926-27 was one of heavy snowfall in most parts of the province and this factor, together with retarded run-off during the spring, caused considerable anxiety as to the probability of extremely high water on the Fraser river with possible damage due to flooding along its lower reaches. Therefore, to meet the situation, a flood warning service for this river was inaugurated and information supplied daily to the press and interested parties. Fortunately, the river did not reach a danger stage. In view of the general value of this flood warning service it is proposed to continue it during the coming year.

Several investigations were made on behalf of the Dominion Lands Branch of the Department of the Interior. One investigation covered a complete engineer's report under the Water Lands Rgulations, on an application for a proposed hydro-electric project on the Meslilooet river.

An investigation is now under way, on behalf of the municipality of Surrey, in connection with their dyking problems on the Serpentine and Nicomekl rivers.

Activities on behalf of the Department of Indian Affairs were greatly increased during the year. As previously stated, three field parties were almost continuously engaged on engineering investigations and construction work throughout the whole period. Many phases of engineering were covered in these investigations and included water storage, irrigation, domestic water supply, sewage disposal, river bank protection work and electric lighting for Indian villages and Indian schools.

Where required, plans, estimates of cost and specifications have accompanied reports on the different projects for consideration by the Department of Indian Affairs.

As an indication of the nature and variety of the different projects reported upon and carried to completion, the following may be cited as typical of the work carried out in this year's program:—

Water Storage.—Storage of 1,600 acre-feet was created on Beaver lake by the erection of an earth-fill dam 230 feet long and 11 feet high, requiring 1,100 yards of material. The water stored will be used for the irrigation of 560 acres of the Anaham I.R. No. 1.

Irrigation.—Work was commenced during the year on one of the largest irrigation systems so far undertaken for the Department of Indian Affairs, that of Canim Lake Indian reserve. The main ditch, approximately six miles long, is to convey about 20 cubic-feet of water per second from Bridge creek to the reserve for the irrigation of about 2,100 acres. It is expected that, with the intermittent labour provided by the Indians, the work will be completed in about three years.

Domestic Water Supply.—To provide water for domestic purposes on the Indian reserve of Chekwelp, a hydraulic ram was installed on Soames creek, pumping to a reservoir of 5,000 gallons capacity. It is expected that eventually the requirements will be twice this capacity daily so provision has been made in the design of the pipe line and equipment for the addition of another ram to take care of these requirements.

An unsuccessful attempt was made to supply Pemberton I.R. No. 1 village with water from an artesian well. The Department of Indian Affairs now has under consideration, on the suggestion of this branch, the removal of the village to a more advantageous site where a supply of water will be available and where sanitary conditions will be better.

Sewage Disposal.—A sewage disposal plant of 5,000 gallons daily capacity has just been installed at the new Lytton industrial school. The effluent from the septic tank is used for sub-surface irrigation of a small garden patch.

A drainage system has been installed in the Indian village of Church House where unsanitary conditions have proved troublesome. Each house is connected to the system which discharges into the sea at medium low tide level. Latrines were also built discharging into the sewer. A connection with the water system provides for the flushing of latrines.

River Bank Protection.—An investigation was made of the cause of erosion of Twascome Reserve, Sechelt I.R. No. 1. It was found that an unauthorized dam constructed on Wilson creek caused an increased flow in the branch of the creek through the reserve, which flooded the banks and passed into the sea across a narrow neck, causing erosion on the beach and the creek bank. Remedies were suggested in the nature of protection works and the removal of the unauthorized dam, but legal advice was recommended before any action be taken.

Electric Lighting.—An electric lighting system is suggested in connection with the water system proposed for Christie industrial school. The flow of the creek from which the water supply for domestic and fire protection purposes is secured, is sufficient to provide, with a short extension of the pipeline, about 5 horse-power for nine months of the year. Such a plant at a very reasonable cost, would provide an economy of about $250 yearly in the operation of the present lighting system.

With the enlargement in industrial development, particularly in the pulp and paper and mining industries, the demand for hydro-electric power is more pronounced, and this year has shown a very satisfactory increase in hydro-electric development. Hydrometric data are constantly in demand by power companies as well as municipalities, towns and cities throughout the province, in connection with their water problems, while hydrometric data obtained by this Service are a large factor in the adjudication of water rights by the provincial authorities.

DISTRICT OF ALBERTA AND SASKATCHEWAN

B. Russell, Acting District Chief Engineer

The stream measurement and power investigatory work of the Dominion Water Power and Reclamation Service in Alberta and Saskatchewan was continued in conjunction with the Irrigation and Drainage activities, referred to in Part III of this report, during the fiscal year ended March 31, 1928.

The whole of the province of Alberta, most of the province of Saskatchewan, and a small portion of northeastern British Columbia is covered from this district office. As lines of communication with the Peace River Block in British Columbia are through Alberta, work in this area is handled from this office and for the same reason the northeastern or Churchill river area in Saskatchewan is under the supervision of the Manitoba office of the service.

Organization

With the amalgamation of the Dominion Water Power and the Reclamation Service in 1923, it became possible to combine all functions pertaining to the investigation, utilization, and administration of water resources in the provinces of Alberta and Saskatchewan under the control of a single field organization with headquarters in the Southam Building at Calgary. As a matter of economy in handling so large a territory, subdistricts have been created and each placed under the charge of an engineer who carries on the hydrometric field investigations as well as those of an irrigation, drainage, or water-power nature. These officers report to and are controlled from Calgary where all data are collected, compiled and filed.

Co-operation

The arrangements with the Montana Division of the United States Geological Survey and the United States Bureau of Reclamation for co-operation in regard to the collection of steam-flow records on international waters along the boundary were continued. These duties arise through the appointment of an engineer from this service to co-operate with a similar engineer of the United States for the purpose of undertaking the measurement and apportionment of the flow in the St. Mary and Milk rivers and their tributaries in the provinces of Alberta and Saskatchewan and in the state of Montana, as provided in an order of the International Joint Commission dated October 4, 1921, in conformity with Article VI of the Boundary Waters Treaty of 1909.

The relations maintained by members of the staffs of the two countries are of a very friendly nature and much valued assistance is given each year by officers of the United States Services to members of our staff in connection with this work.

Looking to the solution of problems in connection with the irrigation systems of the Canadian Pacific Railway Company and the Canada Land and Irrigation Company in Alberta, our staff has co-operated with their officials and engineers to the mutual advantage of both organizations.

In the investigation of hydrometric problems in connection with the operation of the Lethbridge Northern irrigation district, active co-operation was carried out with officials of the district. The usual co-operation with officials of other irrigation and power projects in regard to stream and canal-flow problems was continued with execllent results.

The co-operative arrangements with other departments, the provincial governments, railway corporations, and several municipalities have been continued during the year. Many phases of the water-supply problems of these

organizations have been studied and with their assistance valuable hydrometric data have been obtained which are not only of interest to them, but also of general value.

The usual lectures and demonstrations in connection with hydrometric methods were carried out at the University of Alberta and the University of Saskatchewan.

Hydrometric Survey

During the year ended March 31, 1928, 266 gauging stations were maintained on rivers, lakes, canals and ditches in the following main watersheds: Assiniboine, Athabaska, Battle creek, Belly, Bow, Frenchman, Little Bow, Lodge creek, Milk, North Saskatchewan, Oldman, Peace, Red Deer, Rock creek, Ross creek, St. Mary, Saskatchewan, Sevenpersons creek, South Saskatchewan, Swiftcurrent creek, and Waterton. Of these stations 48 were maintained all year, and 218 during the open water season only. Fourteen of the above stations were maintained for power, 156 for irrigation, 22 for drainage, 12 for domestic water supply, 6 for flood warnings, 41 for international purposes, and 15 for statistical information. In addition to these regular stations, 159 miscellaneous measurements were obtained at 84 other points.

Following a fairly steady winter during which there was a considerable fall of snow, especially in the southern portion of both provinces, the spring run-off for 1927 was materially delayed by cold weather, so that ice conditions existed on many streams until about April 25. On some of the northern streams ice conditions held even to a later date, and it is reported that pack trains crossed the Peace river on the ice below Hudson Hope as late as May 3. A late spring was followed by a summer of almost unprecedented rainfall, especially in the southern portion of both provinces. These rains were, however, not of sufficient intensity and duration to cause destructive floods, but occurred at regular intervals evenly distributed over the whole summer. During July in central and southern Alberta, the country was visited by several violent wind storms. These in certain cases assumed tornadic proportions causing considerable damage to buildings and property. More destructive hail storms than usual were also recorded.

Stormy weather also continued into autumn, causing certain difficulties and delay in harvesting operations. These storms, however, were not so pronounced in the Edmonton and Peace River districts and not nearly so much precipitation was recorded as in the southern and usually drier belts. Beginning with November, cold weather set in and it remained very cold for two months. Early in January a thaw developed which threatened to break up some of the ice-covered streams, and which did cause markedly increased stream flow in many cases, especially in the chinook affected areas. Mild weather continued throughout January and February, causing a large amount of the snow cover to be swept away. Then with March came a variety of weather changes varying from the ordinary cold and windy condition to almost summerlike mildness. This latter condition began about March 16 and held well to the end of the month, causing complete ice break-up on practically all prairie and foothill streams. The suddenness of this break-up, coupled with a condition of thick and tough ice, resulted in many ice jams. Notable amongst these was one which formed on March 29 in the vicinity of Pike lake some 20 miles southwest of Saskatoon on the South Saskatchewan river. This jam was about 30 feet high, 10 miles long and flooded 32 farmers out of their homes for several days. In other areas, especially in Alberta, many small bridges and some larger ones were carried out by ice, making the damage from break-up greater than for many years. These conditions with an unusually large run-off for March ended the year under review.

From a study of the temperature records for twelve meteorological stations well distributed over both provinces, it has been determined that the mean temperature for the fiscal year was slightly above average, while the mean temperatures for the months of November and December were respectively 12 degrees and 14 degrees below average.

PLATE 2

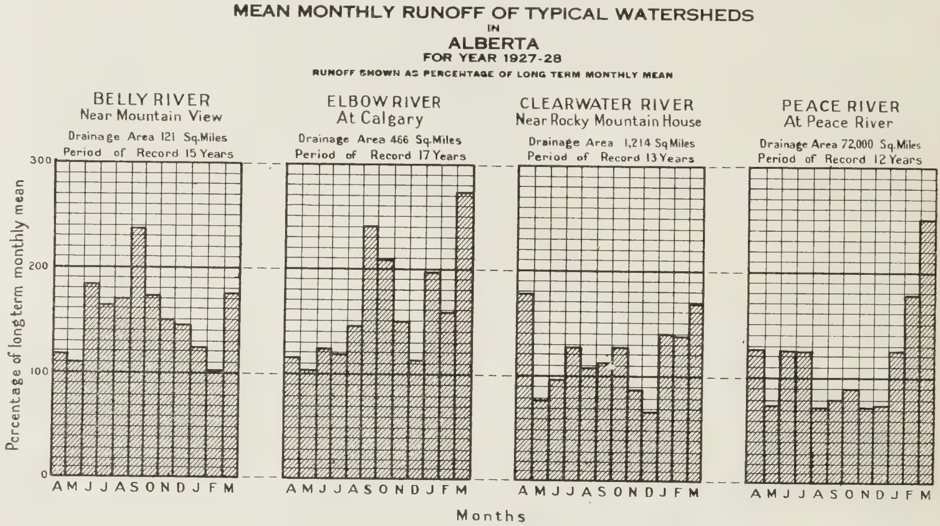
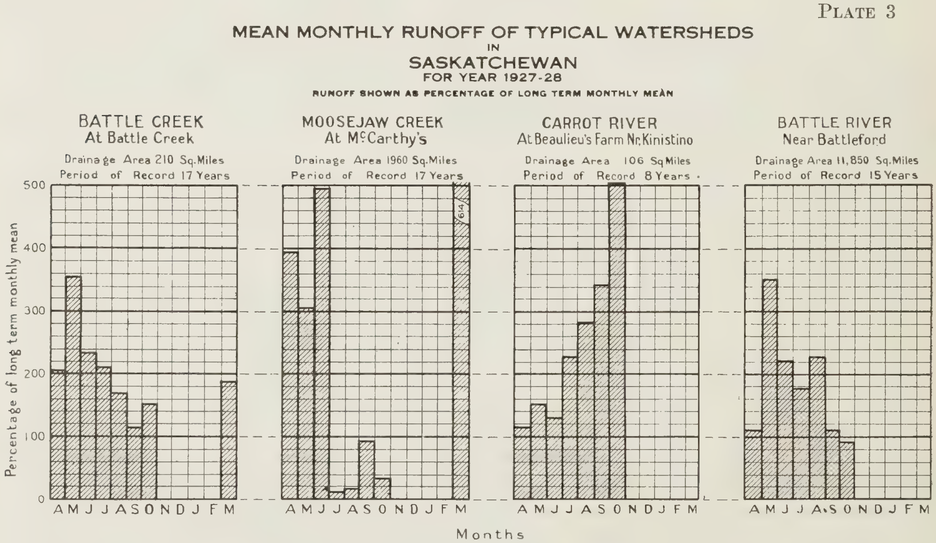


PLATE 3



To illustrate the general run-off conditions in Alberta and Saskatchewan, graphs showing the variation from the mean, month by month, for four typical stations in each province have been prepared and are attached (see Plates 2 and 3). In Alberta the representative stations are: the Belly river near Mountain View, the Elbow river at Calgary, the Clearwater river at Rocky Mountain House, and the Peace river at Peace River. In Saskatchewan they are: Battle creek at Battle Creek, Moosejaw creek at McCarthy's, the Carrot river at Beaulieu's farm near Kinistino, and the Battle river near Battleford.

Considering the Belly river records as indicative of general conditions in southern Alberta, both precipitation and run-off were above normal during the year, the former being 120 per cent and the latter 158 per cent of the long-term mean. The maximum daily run-off during the year was in June when 22·07 second-feet per square mile was recorded on the Belly river. This is the highest daily discharge yet recorded in this area, the highest discharge prior to this year being 20·47 second-feet per square mile. Minimum flow occurred in February and was at the rate of 0·41 second-feet per square mile as compared with 0·18 second-foot per square mile, the lowest prior to this year.

In central Alberta as typified by the Elbow river, the precipitation was decidedly above normal and the run-off 145 per cent of the average. Flood discharges reached a maximum daily run-off of 6·31 second-feet per square mile in June as compared with 25·11 second-feet per square mile, the maximum for period of record. Low flow was at the rate of 0·20 second foot per square mile in January as compared with 0·04 second-foot per square mile, the previously recorded minimum.

For north central Alberta the typical stream selected was the Clearwater river. In this district precipitation was slightly above average and the run-off for the year was 111 per cent of the long-term mean. Maximum run-off reached a daily discharge of 3·29 second-feet per square mile in July as compared with 32·21 second-feet per square mile, the maximum of previous records. The low run-off which occurred in December was at the rate of 0·13 second-foot per square mile as compared with 0·06 second-foot per square mile, the lowest discharge so far recorded.

Northern Alberta as represented by the Peace river shows a precipitation for the year slightly below normal and run-off about 106 per cent of the long-term average. The flood stage reached a maximum daily discharge of 4·88 second-feet per square mile in July as compared with 5·20 second-feet, the highest run-off previously recorded. Minimum daily flow occurred in January at the rate of 0·15 second-foot per square mile, as compared with 0·09 second-foot per square mile, the lowest in the previous twelve years.

In southeastern Saskatchewan, Battle creek, the typical station, shows a record run-off and a high precipitation for the season, the former being 231 per cent and the latter 145 per cent of the long-term mean. The maximum daily flow was at the rate of 7·90 second-feet per square mile in April, representing also the highest run-off on record. The highest flow recorded prior to this year was 5·77 second-feet. Minimum run-off occurred in March and was at the rate of 0·03 second-foot per square mile as compared with no discharge in several previous years.

Typical of southeastern Saskatchewan, Moosejaw creek records show an unusually high run-off of 353 per cent of the long-term mean. The maximum daily discharge recorded was at the rate of 1·53 second-feet per square mile. This occurred in April and is the highest yet recorded, the highest discharge prior to this year being 1·51 second-feet. There was no flow in Moosejaw creek during a portion of the year.

In central eastern Saskatchewan, the typical stream selected is the Carrot river. Precipitation and run-off for this area were above normal, the latter being 158 per cent of the long-term mean. Flood run-off in April reached a maximum daily discharge of 1·04 second-feet per square mile as compared with 4·30 second-feet per square mile, the maximum thus far recorded. Low run-off, also occurring in April, was at the daily rate of 0·004 second-foot per square mile and compares with no flow on various previous occasions.

For central western Saskatchewan, as typified by the Battle river, precipitation was slightly above normal and the run-off was 196 per cent of the average.

The maximum run-off occurred in April and was at the rate of 0·43 second-foot per square mile as compared with 0·97 second-foot, the highest heretofore recorded. Minimum flow occurring in April was at the rate of 0·001 second-foot per square mile as compared with no discharge on various former occasions.

During the year new maximum discharges were recorded on 30 streams although practically no destructive floods occurred.

Current Meter Rating Station

The only fully equipped current meter rating station in Canada is operated by this organization at Calgary. Here all metering instruments used by this service and by many other organizations are rated. At the rating station meters are calibrated as received from the field so that recent measurements can be recomputed if necessary. Following the first calibration the instrument is checked over and, if necessary, repaired. It is then re-rated before being returned to its user. During the fiscal year 1927-28 the station was in operation from May 10 to November 4. A total of 101 current meters were rated, 174 ratings were made and 68 instruments were repaired in various degrees. Of the calibrations made, 1 was for the Department of Public Works; 1 for the Water Rights Branch, British Columbia; 2 for the Great Lakes Power Company; 1 for the Lethbridge Northern Irrigation District; 2 for the Crown Willamette Power Company; and 2 for the Canadian Pacific Railway Company, Department of Natural Resources. The remainder were made for offices of the Service as follows:—Ontario 27; British Columbia 35; Quebec 6; Alberta and Saskatchewan 60; Nova Scotia and New Brunswick 6; and Manitoba 13. Important experimental work was carried out which was covered by a series of 18 experimental ratings; all these data are on file and can be supplied on demand. Several requests for such information were made.

Special Investigations

According to an arrangement in effect since 1921, the Calgary Power Company takes charge of the operation of storage in Lake Minnewanka reservoir during the emptying period, while the filling of the reservoir is in charge of this Service. Pursuant to this arrangement the supervision of operations at the dam at the outlet of the lake was assumed on May 11, 1927, and continued until October 7, when, as the tourist season in the Rocky Mountains park was practically over and as the lake was at upper regulation level, the handling of the reservoir was turned over to the power company.

At the date of the taking over of the supervision of the reservoir for the filling season, an inspection trip was made to the dam in Devil's canyon by officials of this Service and at the same time the snow conditions in the Bow valley were investigated to aid in giving an estimate of the possible run-off. It was feared from knowledge of the amount of snow in the mountains and the lateness of the starting of the run-off that floods might occur and caution was exercised in filling the reservoir until the danger period was passed when the water was brought to upper regulation level.

During the draw-down period in December complaint was received in this office of the formation of an ice jam on the Cascade river near Anthracite and the consequent flooding of some privately owned property. On investigation by officers of this Service it was decided that the jam was not due to operation of the reservoir but would quite probably have occurred under natural conditions of run-off as the draw-down was regulated smoothly and a steady flow maintained.

The applications of the Province of Alberta and of the Montreal Engineering Company of Montreal, Quebec, for the right to develop storage and high head at Spray lakes in the Bow river basin, are still before the Department.

An application for license to use and store the waters of the Bow river within the limits of the Ghost development has been made to the Department by the Calgary Power Company. An investigation has been made on this application by officers of the Service and reports submitted to the Director. In addition the Calgary Power Company are investigating other possible power sites within the province and have made many requests for basic data which have been supplied from this office.

Information has also been supplied regarding stream flow and power sites on the Saskatchewan river to the Saskatchewan Power Commission as well as data regarding pondage for steam plants on the Souris river in Saskatchewan.

Several requests for information regarding small power sites in Alberta and Saskatchewan have been received but as the interested parties have not followed up the receipt of the information by further action no inspections have had to be made.

The office study made in 1926 of the effect that storage for power purposes on the upper tributaries of the Bow river would have on irrigation projects, existing and proposed, on the lower reaches of this river has been completed and in the form of a report under the title " Bow River Flow, Part II," has been forwarded to the Director.

The use and demand for electric energy for light and power is continually increasing in the cities and towns of Alberta and Saskatchewan, and, where it is economically possible, in the rural districts. This demand is causing growing interest in possible hydro-power developments in both provinces.

During 1927 the Calgary Power Company continued the extension of its transmission lines through the southern part of Alberta. Two lines, one along the Macleod branch and one along the Aldersyde branch of the Canadian Pacific railway, to Lethbridge have now been completed. From Lethbridge lines have been carried east to Taber and south to Magrath. The majority of the towns along these lines have signed agreements for the purchase of light and power and the company is also supplying many rural customers. The city of Lethbridge and the company are working under an agreement for the interchange of power whereby the city takes power from the company during periods when the hydro-plants can carry the load and supplies power from its steam plant to the company during periods of low flow in the Bow river. In addition to the new load in southern Alberta, the Calgary Power Company has signed agreements with towns along the Calgary-Edmonton branch of the Canadian Pacific Railway, and are now engaged on a survey for a transmission line to Red Deer upon which it intends to start construction during the coming spring. Inspections of the new transmission lines by officials of this service were made during the summer of 1927 but owing to weather conditions it was not possible to complete the work and a portion still remains to be inspected. Difficulties arose over the purchase of right of way on part of the line along the Macleod branch and several special investigations had to be made by officers of the service before the trouble was finally adjusted.

At Calgary the consumption of power during 1927 was much greater than in 1926 and with the new load in the southern portion of the province, the peak demand taxed the hydro-power plants of the Calgary Power Company at Seebe to the limit during periods of low flow in the Bow river. By using the city of Calgary steam plant and feeding back power from the Lethbridge steam plant, it was possible to carry the load. Careful study of the most efficient use of the available water supply through the plants at Seebe has aided in increasing the output of these plants during the winter.

The investigation of absorption losses in lake Newell reservoir of the Eastern Section of the Canadian Pacific Railway Company's irrigation system, which was started in 1920, was concluded in 1925, and a compilation report of this investigation was completed during the year.

During May the investigation of snow conditions in the Upper St. Mary River basin was again carried out jointly with the District Engineer of the Montana Division of the United States Geological Survey. For six consecutive years this survey has now been made and some very interesting data upon which to base the probable seasonal run-off of the St. Mary river is being compiled.

On the Lethbridge Northern irrigation district canal two separate investigations which have been carried on since 1925 were continued in 1927. The first covers in a comprehensive manner a study of the canal carriage losses from the canal headgates to a point 2½ miles north of the Oldman flume. This study has proved to be most valuable to the district officials as well as other parties interested in canal carriage losses. The second study covers the losses in Keho Lake reservoir. Progress reports for each study have been submitted.

During the year 5 new joint international gauging stations were established and 3 other stations, of which records had been secured for some time past by this survey, were made joint international.

Owing to the unusually wet season coupled with the lack of irrigation, the Battle Creek return flow investigation was rendered impossible during 1927. It is intended to carry forward this study during 1928.

During the fiscal year requests for information on regular gauging stations were received and supplied for 81 stations. Also in addition many miscellaneous requests for data such as temperatures, precipitation, water levels, etc., were given. No flood warning despatches were necessary as dangerous stream stages were comparatively few; daily press information during high water was, however, supplied.

Hydrometric data prepared by this service was used in connection with operation by the Eastern and Western Sections of the Canadian Pacific Railway Company's irrigation system, the Alberta Railway and Irrigation Company, the Lethbridge Northern irrigation system, the Canada Land and Irrigation Company system, the New West irrigation system, the Taber irrigation system, and the Calgary Power Company.

DISTRICT OF MANITOBA

C. H. Attwood, District Chief Engineer

During the fiscal year ended March 31, 1928, the regular stream measurement and power investigatory operations of the Dominion Water Power and Reclamation Service in Manitoba and adjacent districts have been continued.

The scope of the work covered by this district organization comprises the hydrometric, power, storage and reclamation investigatory work in Manitoba and the Churchill river section of northeastern Saskatchewan, and also the hydrometric work in that portion of western Ontario inclusive of and lying to the west of the Nipigon river.

Organization

The local organization of the Dominion Water Power and Reclamation Service, headquartered in the Commercial Building, Winnipeg, was organized in 1912 and the work then instituted has been carried on and extended from time

to time. The duties of the engineers and the hydrometric recorders consist of both field and office work, including surveys, investigations, inspection and supervision of construction, and the preparation of the data collected in report form, for submission to the head office.

Co-operation

The organization works in co-operation with several departments of the federal Government and with the Power Commission and Reclamation Service of Manitoba.

Hydrometric Survey

During the past year 109 regular and 16 miscellaneous stations have been maintained on lakes, rivers and tributaries in the following main watersheds: Nelson, lake Winnipeg, Winnipeg river, lake of the Woods, Rainy lake and English, Red, Assiniboine, Dauphin and Saskatchewan rivers.

Of the above regular stations there were maintained for power and storage 61 all-year, 5 during open water and 6 miscellaneous; for drainage and reclamation throughout the year 9 regular, 24 during open water and 14 miscellaneous. Five regular all-year stations, together with 5 open water were maintained for flood study. On international streams 14 all-year and 8 open water regular stations were maintained, together with 6 miscellaneous. For water supply 4 regular stations were maintained during open water and for statistical purposes 5 all-year stations, while for meteorological purposes 11 stations were maintained continuously. In the above classification a number of stations have been maintained for more than one purpose.

High run-off as compared with the mean for the period of record has prevailed throughout Manitoba during the year, this was especially noticeable in the fall of 1927, when, due to the heavy precipitation, it ran in some cases from 200 to 300 per cent of the mean. Taking the Red river as typical of the southern portion of the province, the run-off was 158 per cent and the precipitation on the watershed 113 per cent of the mean for the period of record. The flood run-off, however, was only 44 per cent of the previous recorded maximum, being 0·592 second-foot per square mile, while the minimum run-off which occurred in February, 1928, was 0·017 second-foot per square mile, as compared with the maximum for the period of record of 0·003.

On the Roseau river high stages occurred from early in April to nearly the middle of June. Precipitation throughout the Roseau watershed during May was excessive and the river rose to the maximum stage for the period of record. From the International Boundary northerly for a distance of fifteen miles the low-lying lands on both sides of the river were under water and owing to the continued duration of the high water condition considerable hardship was occasioned the farmers in that district.

In the mid-western section of the province, as exemplified by the Swan river the average run-off was 173 per cent of the period of record, and in the southwestern section the run-off of the Assiniboine river was 200 per cent of the long-term mean. The flood run-offs were not as high as previous records, that on the Swan river being 5·514 second-feet per square mile, or 79 per cent of the previous maximum, and on the Assiniboine river 0·303 second-foot per square mile or 84 per cent of the previously recorded maximum. The minimum run-off for the year on the Swan river occurred in February with 0·007 second-foot, and on the Assiniboine river in March with 0.006 second-foot per square mile. The minimum recorded for the period of record on these streams were 0·0 and 0·001 second-foot per square mile, respectively.

The precipitation on the Swan river watershed for the year was 101 per cent and on the Assiniboine watershed 95 per cent of the mean.

On the Assiniboine river during May, 1927, flooding occurred although the stages reached at the peak was considerably below those recorded in 1916 and

1923. The wide valley of the Assiniboine in Brandon was flooded and numerous houses located on the flats were inundated to the first floor. Although flooding occurred along the river above Brandon, no particular damage was occasioned. From Portage la Prairie easterly to Pigeon lake the river overflowed its banks and an extensive area was under water for some time as were also certain sections of the provnicial highway.

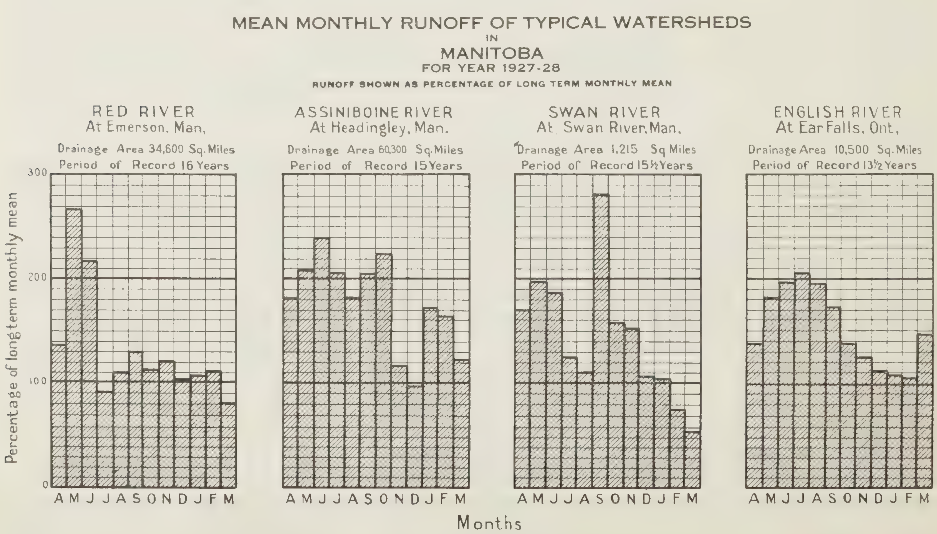
In that section of Ontario drained by the Winnipeg River flood, conditions occurred exceeding any previously recorded. As exemplified by the English river the run-off was 159 per cent of the mean with a maximum of 2·048 second-feet per square mile, the highest recorded, the former maximum being 2·400 second-feet per square mile. The minimum run-off for the year was 0·446 second-foot per square mile as compared with 0·293, the lowest recorded. The precipitation on the watershed of the English river, which is representative of that of the Winnipeg river, was 79 per cent of the mean.

On the English river at Ear falls the maximum discharge was 21,500 second-feet, occurring in July, while above Deer falls, near the mouth of the river, a discharge of 39,500 second-feet was recorded. On the Winnipeg river maximum discharges for the period of record were experienced, a flow of 55,000 second-feet being recorded at Minaki, which is above the junction of the English river, early in June, while in July, at Slave Falls on the Main river, the discharge reached a maximum of 86,600 second-feet. High stages prevailed during the months of May, June, July and August.

On the lake of the Woods the inflow reached record proportions and although the outflow was increased to above 53,000 second-feet the elevation of the lake rose to 1062·9 in May 1927. The greatly increased outflow had the effect of reducing the heads of the power plants at the outlets very considerably and also created flooding along the river with material damage to cultivated tracts, private homes, and to the docks and camps of summer campers. Normal conditions were restored in November and the level of the lake has remained practically stationary during the winter months. In January, 1928, the outflow from the lake was increased to an average of 14,500 c.f.s., and between March 24 and 30 the outflow was further increased to an average of 18,000 c.f.s.

An analysis of the run-off conditions of the year, as represented by the rivers mentioned above, which are taken as typical in the district, is given in the accompanying graph.

PLATE 4



Special Investigations

UPPER RAINY BOUNDARY WATERS

The field investigatory work necessary for the proper consideration of the reference in respect to the Rainy and the Upper Boundary lakes, now before the International Joint Commission, was completed during the past season. The survey party, consisting of 15 men, was in the field from the middle of May until early in October and the work covered Namakan, Kabetogama, Sand Point, Crane, Little Vermilion lakes and also Loon river. The surveys were limited to completing and amplifying the work previously done by the International Boundary Survey and consisted of securing the information necessary to delimit the contours between the shore line and elevation 1130 along these lakes. The field work was greatly facilitated by the use of vertical aerial photographs, taken from a height of 10,000 feet by the Royal Canadian Air Force, and covering the whole of the area involved. Prints of these photographs were used directly as field sheets for the deliniation of the topography, and the assembling and co-ordination of the information so obtained, for the preparation of the final plans, was done by methods developed by the Topographical Surveys Branch. The use of the aerial photographs for this survey resulted in a considerable saving of the time required for the field work, and, in addition, gave a greater accuracy in details than would be obtained by ordinary methods. A further advantage of the photographs is that they supply much information as to the character of the country both within and beyond the limits of the actual survey.

Very good progress has been made with the preparation of the plans and with the completion of data necessary for the reference to the International Joint Comission.

Work of a similar nature has been in progress during the year, by the United States Army Engineers, covering the upper reach of the Upper Boundary waters. This work has been under the direction of the District Engineer at Duluth and close co-operation has been maintained between the Canadian and United States engineers in charge of this work.

LAKE OF THE WOODS FLOWAGE EASEMENTS

To carry out terms of Article 8 of the Convention and Protocol between Canada and the United States for regulaitng the lake of the Woods, signed in July, 1925, the District Engineer, United States Army Engineers, at Duluth, early in 1927 placed an engineering staff at Warroad for the purpose of gathering data incidental to the obtaining of flowage easements up to elevation 1064 on the lands bordering the lake of the Woods in Minnesota. In all about 480 claims were investigated and recommendations made as to the price to be paid for the required easements. In only 10 cases were the owners prepared to accept the recommended prices, so with the exception of these 10 claims condemnation proceedings have been instituted in the United States courts to secure the required easements. Plans outlining the required protective measures for the village of Warroad have been prepared. The District Engineer at Duluth has afforded this office every facility for keeping in touch with the progress of this work and close co-operation has been maintained.

MANITOBA DAIRY FARMS LIMITED, WESTERN PROJECT

In accordance with an agreement entered into between the Minister of the Interior and the Manitoba Dairy Farms Limited for the reclamation of certain lands situated in townships 4 and 5, range 9, east of the Principal Meridian, the company filed the necessary plans showing the works to be constructed and were authorized to construct the necessary works. During the year the company constructed about nine miles of ditch outlined on their plans.

MANITOBA DAIRY FARMS LIMITED, EASTERN PROJECT

In May the Manitoba Dairy Farms Limited made application to the Minister of the Interior for a lease for reclamation by drainage with the option of purchasing at a later date, the vacant and available Dominion lands situated approximately in Townships 1 to 11, Ranges 9 to 17, east of the Principal Meridian. Investigations were made thereafter by engineers of the department throughout portions of this extensive area for the purpose of determining the most feasible method of securing such data as would be necessary to determine the feasibility or otherwise of the project. In consequence, in December a field survey was organized by the Topographical Surveys Branch in co-operation with the Dominion Water Power and Reclamation Service. The field party, in charge of G. J. Lonergan, D.L.S., completed their field investigations about March 1. To determine the timber resources of the area covered in the application, timber cruisers, attached to the staff of the Crown Timber Agency at Winnipeg, made a survey of the area during the winter months.

CO-OPERATION WITH DEPARTMENT OF INDIAN AFFAIRS

In August a survey was made of certain marsh areas in Peguis Indian Reserve No. 1-B for the purpose of ascertaining the feasibility and the probable cost of reclaiming these areas. As a result of the survey a proposed plan for improvement of drainage conditions was prepared, together with estimated cost of the same.

In October an inspection was made of the water-supply system of the Indian School at Sturgeon Landing. A report was prepared and submitted outlining the alterations and extensions recommended to meet the school's requirements for a satisfactory water-supply system.

In September an inspection was made of the sewerage conditions at the Sandy Bay Indian residential school and a report, describing the existing sewerage disposal system, and recommendations for improvements to the same, together with estimates of the cost of said improvements, was prepared and submitted to the Department of Indian Affairs. The repairs and alterations to the system as recommended were carried out and completed under supervision from this office.

At the request of the Department of Indian Affairs this office took charge of the water-supply system at Sioux Lookout Indian school in Ontario and reconstructed the intake works and a portion of the water mains.

At the Fort Alexander Indian school our reports and recommendations for the repairs, alterations and additions required for an adequate water-supply system having been accepted and approved this office was authorized to proceed with the work. A contract was let for the intake works, storage tanks and water mains, the old system being replaced where necessary. This work was completed early in the year.

GREAT FALLS

An extensive construction program was carried on by the Manitoba Power Company during the year in connection with their hydro-plant at Great Falls. The power-house super-structure was completed, affording covering for Units Nos. 4, 5, and 6. Unit No. 4, together with the necessary transformers, high tension coils and switching equipment was completed, installed and placed in service in March. This unit consists of an S. Morgan Smith 200-inch propellor type, high-speed vertical turbine with a manufacturer's rating of 28,000 horsepower, direct-connected to a Canadian General Electric 21,000-kv.a. generator and exciter.

During the summer a ditch was dug to drain certain flooded areas lying back of the railway embankment. A contract was awarded to Carter-Halls-Aldinger Company for completing the rock-fill section of the dam and work was commenced on this contract in January, 1928. This work involves raising the rock toe-wall to a sufficient height to prevent the earth-fill from slipping over the top and filling in the space between the toe-wall and the main rock-fill dam with a mixture of clay, and finally crushed stone, and also the reinforcing of the east earth embankment with rock or other satisfactory material.

During the year the erection of the transmission line from the Great Falls plant to the Central Manitoba Mines was completed and power is now being supplied to two mining companies in that field. The 110,000-volt transmission line from the Great Falls plant to Winnipeg via Selkirk was constructed during the year and this line is now in service.

To meet the increasing power requirements contracts have been let for the complete installation of Units Nos. 5 and 6 and preliminary work in connection with the installation of these two units is in progress.

POINT DU BOIS

In June a contract was let by the city of Winnipeg hydro-electric system to Macaw and Macdonald, contractors, to excavate an artificial channel through the rocky barrier at Eight Foot falls on the Winnipeg river. The work involved the cutting of a channel 150 feet wide to elevation 911 for a distance of about 410 feet for the purpose of securing better control of tailwater conditions at Point du Bois power station. Work was commenced in July and is still in progress; the total quantity of rock to be moved was estimated at 25,000 yards.

Owing to high-water conditions and ice movements in the spring of 1927, the steel flashboard structures erected during 1925 on the spillway sections of the dam were almost completely wrecked. During the year this demolished structure was replaced by building a series of concrete piers on the spillway sections, the work being completed in December 1927.

KEEWATIN POWER COMPANY

In October the Keewatin Power Company, in accordance with the terms of an agreement with the Department in 1924, installed the second stop-log winch on the Norman dam. The winch was given a very thorough test and proved satisfactory.

DISTRICT OF ONTARIO

N. Marr, District Chief Engineer

Organization

During the fiscal year ended March 31, 1928 the regular stream measurement and power investigatory work of the Dominion Water Power and Reclamation Service in the Province of Ontario have been carried on.

This was done in accordance with the terms of a co-operative agreement between the Department of the Interior and the Hydro-Electric Power Commission of Ontario.

The work of the Ontario Hydrometric Survey was carried on under the supervision of the District Chief Engineer with a head office in Ottawa. The greater part of the field work was done by a field staff with an office in North Bay, while certain stations in the eastern part of the province and 15 stations on

streams tributary to the Ottawa river in the province of Quebec were, for reasons of economy and convenience, handled from the head office at Ottawa. The hydrometric investigations in that part of the province west of, and including, the Nipigon river were, as in previous years, under the direction of the district office in Winnipeg.

Co-Operation

In pursuing the field and office investigations the closest co-operation has been maintained with the officers of the Hydro-Electric Power Commission of Ontario. Particular reference should also be made to the following corporations which have given the engineers of the district valuable assistance and information:—the Abitibi Power and Paper Company; the International Nickel Company of Canada; the Kaministiquia Power Company; the Mattagami Pulp and Paper Company; the Mississippi River Improvement Company; the Pigeon River Lumber Company; the Spanish River Pulp and Paper Company; the Spruce Falls Company; the Northern Ontario Power Company and the Gatineau Power Company.

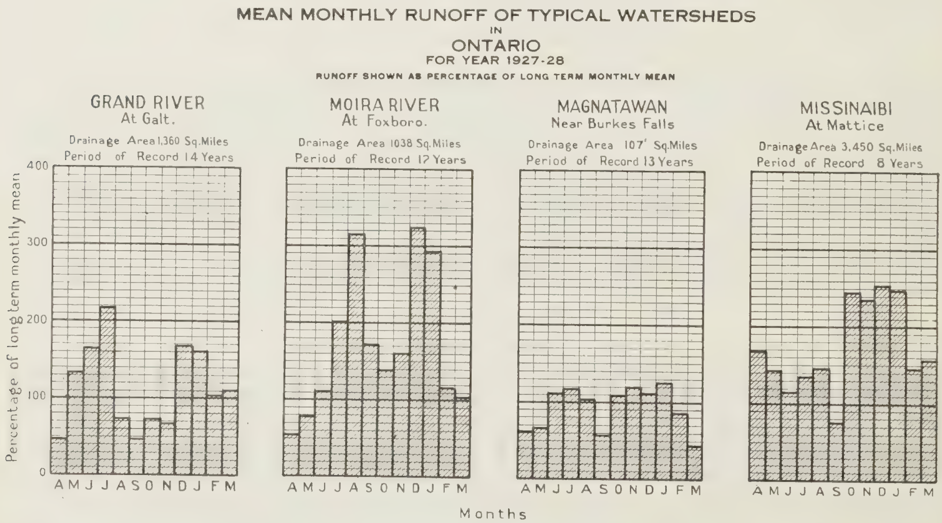
Hydrometric Survey

During the fiscal year ended March 31, 1928, 62 regular stations were maintained on rivers and tributaries in the following watersheds: Hudson bay, lake Superior, lake Huron, lake St. Clair, lake Erie, lake Ontario and Ottawa river.

Of these, 56 were maintained throughout the year for power purposes, 5 were maintained throughout the year, and 1 during spring run-off for flood study, and 1 on an international power control problem.

For the purpose of illustrating the run-off conditions throughout the province, the mean monthly discharge of four typical streams have been computed in terms of the mean for the period of record. This variation, month by month, is shown by the attached graph (see plate 5).

Plate 5



The stations selected are, the Grand river at Galt, the Moira river at Foxboro, the North Maganatawan river at Burk's falls and the Missinaibi river at Mattice.

In the southwest portion of the province, as typified by the Grand river, precipitation was normal and the run-off 101 per cent of the long-term mean. Flood run-off reached a maximum daily discharge of 19·650 second-feet per square mile in March, as compared with 22·125 second-feet per square mile, the maximum for the period of record. The low run-off which occurred in September was at the rate of 0·102 second-foot per square mile as compared with 0·036 second-foot per square mile, the lowest so far recorded.

For the eastern portion of the province the stream selected is the Moira river at Foxboro. The precipitation was a little above normal and the run-off for the year was 113 per cent of the long-term mean. Flood run-off reached a maximum daily discharge of 3·410 second-feet per square mile in April as compared with 12,003 second-feet per square mile, the maximum for the period of record. The low run-off which occurred in September was at the rate of 0·169 second-foot per square mile as compared with 0·014, the minimum discharge so far recorded.

In the North Bay district the typical stream selected is the North Magnatawan river at Burk's Falls. The precipitation was less than normal and the run-off for the year was 81 per cent of the long-term mean. Flood run-off reached a maximum daily discharge of 7·150 second-feet per square mile as compared with 23·271 second-feet per square mile, the maximum for the period of record. The low run-off which occurred in September was at the rate of 0·262 second-foot per square mile as compared with 0·008, the minimum discharge so far recorded.

For the northern portion of the province the typical stream selected is the Missinaibi river at Mattice. The precipitation was above the average and the run-off for the year was 168 per cent of the long-term mean. Flood run-off reached a maximum daily discharge of 6·800 second-feet per square mile, as compared with 10·235 second-feet per square mile, the maximum for the period of record. The low run-off which occurred in March was about 0·150 second-foot per square mile. This is only an approximation however, as the gauge readings were affected by back-water due to the ice cover on the stream at the time. The lowest open water flow occurred in September and was at the rate of 0·198 second-foot per square mile as compared with 0·047 second-foot per square mile, the lowest daily discharge on record.

Special Investigations

During the year the analysis of the water and storage resources of Ontario was continued in close co-operation with the provincial authorities.

On the Niagara river special studies were continued of river slopes, of the effect of diversions in governing pool levels and of the discharge of the river referred to the Buffalo breakwater gauge. These studies were carried out in close co-operation with the investigations being made by the Special International Niagara Board appointed to report to the Governments of Canada and the United States upon the matter of the preservation of the scenic beauty of Niagara falls.

On the St. Mary river at Sault Ste. Marie officers of the Ontario staff of the Dominion Hydrometric Survey afforded further assistance to the International Lake Superior Control Board in the re-calibration of the discharge through the dam controlling the level of lake Superior.

DISTRICT OF QUEBEC

L. G. Denis, District Chief Engineer

Work was continued by the Dominion Water Power and Reclamation Service in the province of Quebec on basic water-power investigations and related matters during the year in conformity with the co-operative agreement between the Department of the Interior and the Quebec Streams Commission. This comprises the maintenance and operation of a number of hydrometric stations throughout the province established to supply reliable data as a sound basis for the intelligent development and utilization of Quebec's vast water-power resources.

Organization

The Quebec work is under the District Chief Engineer whose office is at 961 Inspector Street, Montreal, close co-operation being maintained with the Quebec Streams Commission whose head office is located in the same city.

Co-operation

The investigations are carried on along definite lines in a well balanced co-operation with the Quebec Streams Commission, but, in addition to this many large corporations and private organizations interested in the information secured, supply very generous assistance in co-operating with the service in many of its activities. Among the latter organizations may be mentioned the Shawinigan Water and Power Company, Duke-Price Power Company, Gatineau Power Company, Southern Canada Power Company, Price Brothers and Company Limited, Laurentide Power Company, Quebec Power Company, Ontario Paper Company, Lower St. Lawrence Power Company, Henry Atkinson, Ltd.

Hydrometric Survey

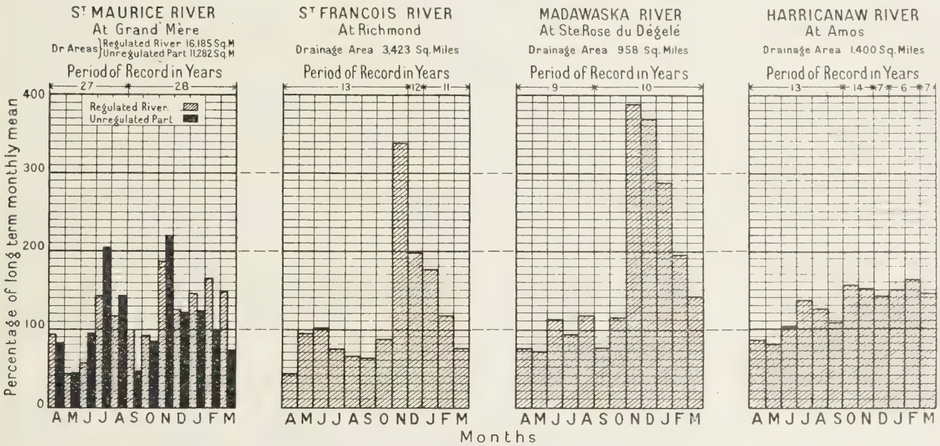
During the fiscal year ended March 31, 1928, 88 gauging stations were maintained on rivers and lakes in the following main watersheds: Ottawa, St. Maurice, St. Francois, Saguenay, other northern and southern tributaries of the Middle and Lower St. Lawrence, Nottaway and Harricana rivers. Of these 68 are all year discharge record stations, one is operated for discharge records during the open season only and 14 are operated all-year for the observation of water levels only. Of the total, 8 are for storage regulation, 68 others are maintained for power and 7 for both flood and power studies. In addition to these miscellaneous measurements were obtained at 19 other points. The slight decrease in the number of stations is mainly due to the discontinuation of many water-level stations in connection with the Prairies river special investigation. As a consequence of very early persistent thaws in March, 1927, the usual spring freshets were much diminished and the low precipitation which followed also contributed to the subnormal run-off during the early summer; higher rainfall later on caused slightly increased run-off except in the Eastern Townships where it remained noticeably below normal up to November. During the latter month two unusual flood periods were recorded, one at the beginning of the month which was remarkably intense, but restricted to a small area near the centre of the settled portion of the province; the other flood period took place about the middle of the month and was felt all over the province but less in the northern position; both floods were caused by heavy continuous rains during a few days preceding. As a further result of these floods and of a comparatively late and not severe winter the run-offs during the latter season were well above

normal. During the fiscal year the temperature ruled slightly above the average and a compilation from records of seven representative stations distributed over the province gave a mean yearly temperature for the year of 37·93 degrees against 37·59 degrees for the corresponding average of previous years.

For the purpose of illustrating the general run-off conditions in Quebec, graphs showing the variation from the mean, month by month, for four typical stations have been prepared and are attached (see plate 6). The stations selected for this province are at Grand'mere for the St. Maurice river, Richmond for the St. François river, Ste. Rose-Dégéle for the Madawaska river and Amos for the Harricana river.

PLATE 6

MEAN MONTHLY RUNOFF OF TYPICAL WATERSHEDS
IN
QUEBEC
FOR YEAR 1927-28
RUNOFF SHOWN AS PERCENTAGE OF LONG TERM MONTHLY MEAN



On the north side of the middle St. Lawrence, as typified by the St. Maurice river, precipitation was above normal but the run-off for the year was 97 per cent of the long-term mean, the difference being accounted for by an increased accumulation in storage reservoirs in the upper basin. Flood run-off reached a maximum daily discharge of 4·3 second-feet per square mile in April as compared with 10·7 second-feet per square mile, the maximum for the period of record. The low run-off which occurred in September was at the rate of 0·84 second-foot per square mile as compared with 0·20 second-foot per square mile, the lowest so far recorded.

For the southern portion of the province, the typical stream selected is the St. François river. The precipitation was above the average and the run-off 110 per cent of the long-term mean. Flood run-off reached a maximum daily discharge of 17·7 second-feet per square mile in November as compared with 18·1 second-feet per square mile, the maximum for the period of record. The low run-off which occurred in August was at the rate of 0.35 second-foot per square mile as compared with 0·22 second-foot per square mile, the lowest so far recorded.

For the eastern portion of the province, south of the St. Lawrence, the typical stream selected is the Madawaska river. The precipitation was above the average and the run-off for the year 134 per cent of the long-term mean. Flood run-off reached a maximum daily discharge of 7·7 second-feet per square mile in November as compared with 10·8 second-feet per square mile, the maxi-

mum for the period of record. The low run-off which occurred in April was at the rate of 0·33 second-foot per square mile as compared with 0·05 second-foot per square mile, the lowest so far recorded.

For the northern portion of the province, the typical stream selected is the Harricana river. The precipitation was above normal and the run-off for the year was 116 per cent of the long-term mean. Flood run-off reached a maximum daily discharge of 3·4 second-feet per square mile in May as compared with 6·6 second-feet per square mile, the maximum for the period of record. The low run-off which occurred in March was at the rate of approximately 0·50 second-foot per square mile as compared with 0·14 second-foot per square mile, the lowest so far recorded.

Special Investigations

Special efforts were made throughout the year in obtaining from all possible sources further up-to-date information on developed and undeveloped water-power of the province; this information was classified and summarized for ready reference and as all surveyed or explored rivers of the province are now fairly well covered it is most useful in supplying available reliable data in answer to numerous requests for information required for preliminary studies in power development and industrial expansion. This material also forms part of the basis of the Water-Power Resources Inventory, including the preparation of power river synopses.

Less time was spent on the special water level and flow investigation of Prairies river as the actual start made during the year on the construction of this project indicated that the object of our investigation had been reached in making available sufficient information to elucidate various aspects which had to do with the development of this power site. The investigation has now merged into our regular hydrometric work.

The exhaustive list of Quebec water-powers compiled by this service in co-operation with and submitted to the Quebec Streams Commission last year was brought up to date; this work has just been completed and it is expected that it will be published by the Quebec Streams Commission in the very near future.

DISTRICT OF THE MARITIME PROVINCES

K. G. Chisholm, District Chief Engineer

The activities of the Dominion Water Power and Reclamation Service in securing fundamental data relative to water-power resources were continued in the Maritime Provinces during the fiscal year ended March 31, 1928.

Information obtained since the activities of the service were extended into the Maritime Provinces has been the basis of the marked activity in water-power development during the past eight years. Although there are probably a greater number of small water-driven mills such as saw-mills, grist-mills and carding mills in the Maritime Provinces than in any one of the other provinces in Canada, it is only since 1920 that there has been any considerable progress in the construction of modern and efficient hydro-electric generating stations. Formerly in the total absence of any systematic run-off data it was generally believed that, with the exception of one site at Grand Falls on the St. John river, the Maritime Provinces did not possess important water-powers.

The investigations and surveys of the Dominion Water Power and Reclamation Service, begun in 1915, giving accurate preliminary data on many sites and demonstrated by stream-flow records that the run-off greatly exceeded previous estimates showed beyond a doubt that the water-power resources were of very

considerable importance. Public interest was aroused which soon led to active development and power commissions were formed in Nova Scotia and New Brunswick.

Since 1920 entirely new plants with a total capacity of 52,844 horse-power have been constructed. Additions to older plants to the extent of 4,560 horse-power have been made. Two plants totalling 84,300 horse-power are under construction, of which 80,000 horse-power will be at Grand Falls. Several important developments in both Nova Scotia and New Brunswick are actively projected for the near future, which will, when completed, add 50,000 horse-power to the water-power installation of these provinces.

Organization

The work of the Dominion Water Power and Reclamation Service in this district follows along the lines of the agreements of 1919 between the Department of the Interior and the Governments of Nova Scotia, New Brunswick and Prince Edward Island. The most important activity is the systematic acquirement of run-off data which is being done by the standard methods of the service. This work is fundamentally important as it provides the indispensable basic data without which estimates of water supply and power are impossible.

Secondary to this important work are investigatory surveys of power and storage whereby the more easily obtainable physical data are made available to the public. This work in general follows the trend of development and more often than not is undertaken at the special request of governmental, municipal or private interests projecting actual construction.

For the three Maritime Provinces a single district office is maintained at 193 Hollis street, Halifax.

Full co-operation is maintained with the provincial governments, particularly with the Nova Scotia Power Commission and the New Brunswick Electric Power Commission which are actively engaged in the development and distribution of hydro-electric power. The Nova Scotia Power Commission possess generating stations at St. Margaret Bay, Sheet Harbour and Mahone with a total capacity of 28,440 horse-power, and the New Brunswick Electric Power Commission generate 11,100 horse-power on the Musquash river. Both organizations are planning further development. The Dominion Water Power and Reclamation Service has been closely connected with all the commission's activities and has rendered material assistance by supplying the fundamental stream-flow data and the preliminary power reports on which their projects were based, by active assistance in the more detailed surveys preceding construction and in certain matters dealing with design.

The Service has also co-operated with private corporations, notably in such cases as the Bathurst Company, Limited, and the Avon River Power Company in important hydro-electric developments. Municipal undertakings, of which there are a considerable number, especially in Nova Scotia, have been assisted in a similar manner.

Hydrometric Survey

Stream gauging was under way at 33 regular gauging stations, 20 in Nova Scotia, 10 in New Brunswick, and 3 in Prince Edward Island. By a careful selection of stations practically all of these produce records of first class accuracy. Some of them have been maintained since the first extension of the Dominion Water Power and Reclamation Service activities into this district. With the exception of two rivers in Nova Scotia and two in New Brunswick on which records are obtained for general statistical purposes, all of the gauging

stations are on important power streams. They are also strategically located so that records are of value in arriving at estimates, not only on the streams gauged, but also on others in territory adjoining them. In Prince Edward Island where there are no large power sites, poor control and excessive variation from the operation of numerous mills makes it extremely difficult to obtain accurate records. Gauging stations are maintained on three representative streams to give at least some indication of the run-off characteristics of the island.

Three new gauging stations were established during the year. One of which is at Scotsville at the outlet of lake Ainslie on the southwest Margaree river. The main station on this river, situated at the most advantageous site, is several miles below the lake, but, in connection with power studies now being carried on by the Nova Scotia Power Commission, it is desired to ascertain the outflow of the lake itself and for this purpose the Scotsville station was established early in December at the request of the commission. It will be maintained for about one year, or until a satisfactory comparison can be deduced of the run-off at both gauges by means of which the records at the permanent station can be used for computing the outflow from lake Ainslie since 1919.

By request of the New Brunswick Electric Power Commission a station which it is proposed to maintain for a year or two was installed on the Petitcodiac river between Salisbury and river Glade.

The matter of obtaining run-off records of the Liverpool river in Nova Scotia has been under consideration for some time. A station established below lake Rosignol in 1917 was discontinued in 1920 because of interference from regulation on lake Rosignol and the difficulty of securing measurements. During the present year this station was re-established. Daily gauge readings were begun at the new gauge below the dam and also at a gauge in the lake. From the records obtained at these two gauges the natural run-off for weekly or ten-day periods will be deduced and will be of value in the study of the power available from this river. In order to facilitate the making of stream measurements a cable and car were erected during the month of October.

The year has been one of high run-off throughout the Maritime Provinces. Following a winter of generally subnormal snowfall the spring run-off in 1927 was less than usual except in northern New Brunswick where the usual winter conditions had prevailed. The summer and fall months of 1927 were very rainy and the winter 1927-28 unusually mild and open so that for the nine-month period, June to February, monthly mean run-off figures were consistently above the average. Although in the month of March the run-off was again low as a result of the mild winter and very light snowfall, nevertheless, the long periods of high-water during the summer, fall and winter months combined to give yearly averages everywhere in excess of the long-term means.

On August 24 a torrential rain occurred which centred in the Annapolis Valley district of Nova Scotia and extended from central Nova Scotia to southern New Brunswick. At Annapolis Royal near the storm centre 5·65 inches fell in less than one day, of which 2·4 inches fell between five o'clock and eight o'clock in the evening. Heavy damage was done to crops, highways, small bridges and culverts.

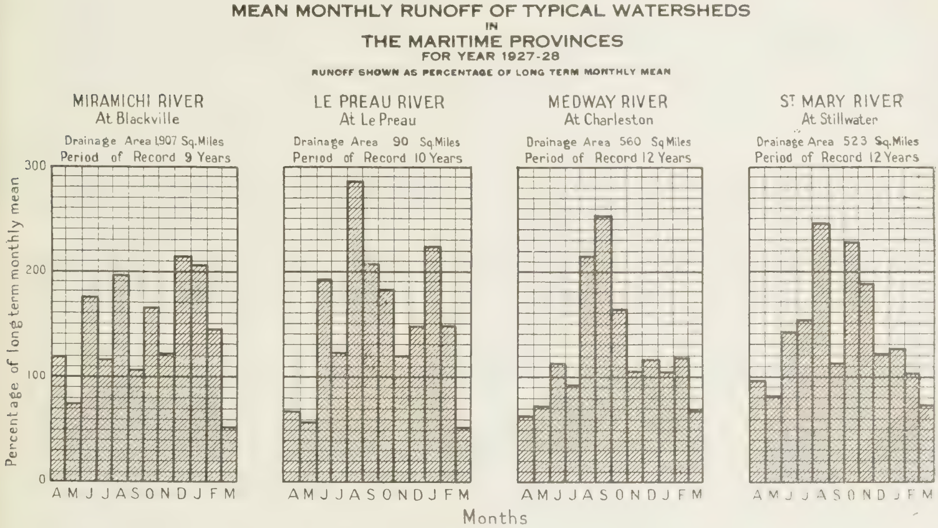
Snow cover was exceedingly light in most parts of Nova Scotia and New Brunswick although in certain districts such as Cape Breton and the Upper Saint John Valley more normal conditions prevailed. In southern New Brunswick little snow fell after the thaw of January 25. Here and over the major portion of Nova Scotia the roads were open for motor traffic during the greater part of the winter.

For the purpose of illustrating the general run-off conditions in the Maritime Provinces graphs showing the variations from the mean, month by month, for

two typical stations in each province are given on Plate 7. The stations selected are the Lepreau and Miramichi in southern and northern New Brunswick respectively, the Medway river for western Nova Scotia, and the St. Mary river for eastern Nova Scotia.

In northern New Brunswick as typified by the Miramichi river the run-off was 127 per cent of the long-term mean. Flood run-off reached a maximum of 20·0 second-feet per square mile on April 24 as compared with 52·5 second-feet per square mile, the maximum for the period of record. The low run-off which occurred in March was at the rate of 5·2 second-feet per square mile as compared with 0·17 second-foot per square mile, the lowest so far recorded.

PLATE 7



For southern New Brunswick the typical stream selected is the Lepreau river. The run-off for the year was 125 per cent of the long-term mean. Flood discharge reached a maximum of 26.8 second-feet per square mile in December as compared with 167 second-feet per square mile in the disastrous flood of April 30, 1923. The low run-off for the year of 0·76 second-foot per square mile occurred on several days in June, July, August, September and October, whereas an absolute minimum of 0·03 second-foot per square mile was recorded in 1921 and again in 1923.

On the Medway, which is selected as typical for western Nova Scotia, the run-off was 103 per cent of the long-term mean. Flood run-off reached a maximum of 6·1 second-feet per square mile as compared with 14·5 second-feet per square mile in March 1920. The low run-off which occurred in July was at the rate of 1·2 second-feet per square mile as compared with 0·04 second-foot per square mile in 1921, the lowest during thirteen years of observation.

In the eastern part of Nova Scotia the precipitation was above normal, amounting to 61·79 inches at the Stillwater gauge on the St. Mary river where the run-off for the year was 127 per cent of the long-term mean. The highest flow of 31·4 second-feet per square mile occurred on October 20, as compared with a flood of 41·0 second-feet per square mile on April 1, 1925. The low run-off occurred in September and was at the rate of 0·45 second-foot per square mile. The minimum for the period of records, thirteen years in duration, was 0·04 second-foot per square mile and occurred in September, 1921.

Special Investigations

A considerable number of special investigations were undertaken during the fiscal year, principally in connection with hydro-electric developments and projects in various parts of the district. The first was on the south branch of the Montague river in Prince Edward Island where surveys were carried on in April and again in August for the Montague Electric Company on the basis of which a small hydro-electric plant of 160-horsepower capacity was constructed.

A considerable amount of office work was done in connection with the new 5,000-horsepower generating station of the Nova Scotia Power Commission at St. Margaret Bay. This included the design of the surge tank and studies of turbine performance, regulation, water hammer and pipe line gradients.

In the month of May and again in August, surveys of the McGill and Curl Hole storage basins were undertaken for the town of Middleton. The load on the municipal plant had grown to the point where added storage capacity was required. The service was requested to advise which of two basins would be to the economic advantage of the town, to determine the amount of storage that would be obtained, with the consequent extent of flooding, and to submit data upon which cost estimates could be made and tenders let for construction. As a result of this work and the comparative studies following it, the town was advised to proceed with construction at the Curl Hole basin; this was done and the dams were practically completed at the end of the fiscal year.

During June the service determined the water losses caused by log driving at St. Margaret Bay. The log driving extended over a period of about three weeks and during the greater part of this time it was necessary to keep an engineer in practically constant attendance at the site of the work. By means of repeated measurements and gauge readings at half hourly intervals a fairly close check was kept of the losses. This work was undertaken at the request of the Nova Scotia Power Commission which had made considerable channel improvements and had taken the driving of logs out of the lumber operators' hands in order to minimize the very serious losses that had occurred in previous years.

Another special investigation undertaken early in the year was an inspection of one of the principal tributaries of the St. John river in the state of Maine.

In July a power and storage survey was commenced of the Herbert river between Windsor and Halifax. A party was engaged on this work for three weeks and some further surveying remains to be done next season before the investigation is completed. Based on the preliminary data obtained, a tentative report was prepared for the Eastern Trust Company, Halifax, and also for the Nova Scotia Power Commission at whose direct request the investigation was undertaken.

In connection with studies by the New Brunswick Electric Power Commission of the power available from the Meductic Rapids site on the St. John river, the Dominion Water Power and Reclamation Service were requested to make an examination of the storage possibilities on the Tobique river which is one of the most important tributaries of the St. John lying wholly in Canada. In response to that request a reconnaissance survey of the two largest lakes, Long lake and Trousers lake, was carried out in September and a report submitted to the commission. These lakes are extremely inaccessible and were reached by an overland journey from Ixbow on the Tobique river.

Certain matters pertaining to head office activities of the Service were attended to, such as the preparation of data for the annual bulletin on the progress of water-power development, and for the *Directory of Central Electric Stations*. A great many requests for water power and run-off data from many different sources were complied with.

PART III

IRRIGATION

J. S. Tempest, Commissioner of Irrigation

Stormy weather delayed field operations in Alberta and Saskatchewan until early in May, but favourable conditions which followed produced heavy growth with every prospect of an abundant crop. This prospect was not entirely realized, however, for an early snowfall accompanied by low temperatures resulted in loss of crop in certain areas. This unfavourable weather, which prevailed throughout September, recurred with greater severity in November and caused the abandonment of all harvesting and threshing operations. In one irrigation district, in fact, about 60 per cent of the grain crop was still in stook at the end of February.

The well distributed and ample rainfall during the growing season greatly reduced irrigation requirements and the use of water was largely confined to domestic and stock watering purposes, although there was some irrigation of hay crops. These conditions enabled the operating staffs to carry out much maintenance and replacement work, and to clear noxious weeds from canal rights of way.

The heavy May rainfall greatly reduced the demand for surveys of farm ditches and, although the policy of aiding and advising irrigators was continued, many of the ditches, which had been surveyed in anticipation of a dry period during the growing season, were not constructed.

In the longer established irrigation districts where soil moisture conditions have become critical, owing to the rise of the water table consequent upon the constant application of water, many farmers requested information and advice as to the water requirements of their crops. In such cases soil moisture tests were made and the condition of the soil in the root feeding zones of the crops was determined.

The importance of seepage and alkali problems which have been under investigation for several seasons is emphasized by the fact that urgent requests have been received for advice and co-operation. This work together with the classification of irrigable lands was continued throughout the season.

The ten-year period of investigation of the "Duty of Water" was completed with the close of the season. Results obtained over this period will in due course be co-ordinated and compiled in such manner as to be readily accessible and available to those interested in the problems connected with the duty of water and the water requirements of various crops, soil conditions and rotations.

The area devoted to sugar beets continues to increase. But for the unfavourable weather during the harvest period, a record crop would have been harvested. The guaranteed price per ton at the Raymond factory in 1927 was $1.25 higher than in 1925. It is also interesting to note that the percentage of sugar in the beets delivered has increased in the same period by some 3·46 per cent.

Water Administration

During the calendar year 1927, 51 applications were filed for the use of water under the Irrigation Act, and 63 licences were issued.

At the end of the year there were 1,044 water licences in good standing, 22 temporary permits, 223 authorizations and 202 projects under investigation, excluding ice permits which are issued annually.

In addition to the major irrigation projects in Alberta operated by irrigation districts and companies, the irrigable areas on privately owned projects, either licensed or authorized, are as follows:—

	Acres
Alberta	62,566
Saskatchewan	42,860
Total	105,426

Many of these projects are incompletely developed and further progress is likely to be slow until land values increase but the acquisition of water rights is a necessary protection for future years and is often associated with excellent results in individual cases.

Evaporation.—A preliminary compilation of evaporation data for the two provinces has been made for the purpose of facilitating administration and it appears that the normal annual evaporation from a free water surface varies from 20 inches in the north to 45 inches in the south, according to location. The yearly variation is liable to be plus or minus 20 per cent and when applying experimental results to large reservoirs it is necessary to allow for the seasonal effect of depth and operation on the temperature of the water. Considerable local information has already been collected and further research is in progress.

Crop Results.—A study of statistical and experimental data suggests that the efficiency of crop growth is greatest when the moisture available and used bears a certain relation to the evaporation from a free water surface. The actual ratio is affected by the kind of crop as well as the physical and fertility conditions of the soil, but it is possible to determine the crop to be expected under variable climatic conditions for an average soil.

The economic value of any irrigation project depends on the improvement in crops under irrigation as compared with those grown under natural conditions and the method now being elaborated will assist in estimating the normal crop to be expected with and without supplementary moisture. The economic duty of water varies considerably in different sections of the territory covered and is very largely influenced by evaporation as well as by precipitation.

Weed Growth in Streams.—A general increase of precipitation has resulted in complaints of hay lands being flooded in various districts and where these are associated with lakes having flat outlet channels it is difficult to suggest remedial measures at moderate cost. The problem is complicated by the growth of aquatic weeds in the outlet river channels obstructing the flow and extending the period of flood. Special study is being given to the conditions with respect to water temperature and stream velocity under which weed growth is possible.

Inspection Work

The usual routine field work in connection with the administration of the Irrigation Act, consisting of the investigation of new applications which involve the making of surveys and the preparation of plans, and the inspection of operating projects was continued throughout the season in conjunction with canal and stream measurements and the study of losses in canals and reservoirs. The following is a summary of work carried out in each district:—

District	Gauging stations	Inspections	Surveys	Gaugings
South Saskatchewan	12	28	6	113
North Saskatchewan	11	22	3	54
Boundary	71	34	11	465
Medicine Hat	37	45	14	183
Calgary	13	11	5	109
Lethbridge and Vauxhall	14	13	4	150
Cardston	38	19	7	312
Macleod	13	26	5	148
Banff	24	9	2	210
Edmonton	14	37	3	57
North Alberta	18	54	10	136
Totals	265	298	70	1,937

Abnormal rainfall conditions obtained throughout the field season over the greater portion of the two provinces. As a direct outcome of these conditions very little actual irrigation was practised and fewer new applications for water rights were filed. A number of complaints were investigated arising from abnormal flooding conditions. In most cases it was found these were attributable to the wet season.

Watermasters.—The watermaster warrants issued in 1926 remained in force this year. These were six in number, one for the engineer in charge of each of the six inspection districts in Alberta and Saskatchewan which extend down to the international boundary, viz: Macleod, Cardston, Lethbridge and Medicine Hat districts in Alberta; Boundary and south Saskatchewan districts in Saskatchewan. The complaints received in the territory covered by the watermasters were the outcome of excessive flooding conditions. As a result of the plentiful rainfall during the spring and throughout the greater part of the growing season very little water was used for irrigation purposes, consequently complaints as to illegal diversion of water were not in evidence.

Domestic Water Supplies.—An adequate supply of water for domestic and stock-watering purposes is of great importance to settlers and becomes a very vital matter in the semi-arid region of southern Alberta and southern Saskatchewan and in certain portions of the Peace River district. Very few perennial streams exist in these localities and there are vast areas whose drainage is carried by water-courses, creeks and rivers having only a periodic flow, but by the expenditure of some labour and very little actual cash the settlers can in many cases provide water supplies lasting the entire year by constructing earth dams.

The problem is becoming of greater importance as settlement increases for, although many of these domestic water supplies have been legalized, there are a large number constructed without authority. It has been, and still remains the policy of the department when unauthorized works of this kind are noticed to advise the owners of the procedure necessary to legalize such works in accordance with the Irrigation Act. Increased settlement of the country will impose greater demands on the available water supply and it seems only a question of time when the Irrigation Act will have to be more strictly enforced in this respect. The inspecting engineers are available at all times to aid settlers in planning, constructing and maintaining their works.

Municipal Water Consumption Data

These data have been collected for a number of years and the records compiled therefrom are submitted in the tables appended. The department is indebted to the various towns and cities for their co-operation in furnishing the monthly records.

Cities and Towns in the Province of Alberta—Record of Daily Water Consumption in Imperial Gallons for the year 1927

Month	Athabaska—Population 450						Bassano—Population 1,000					
	Daily Average for the month	Per Head for domestic purposes	Per Head for industrial purposes	Per Head for other purposes	Per Head for all purposes	Unaccounted for	Daily average for the month	Per Head for domestic purposes	Per Head for industrial purposes	Per Head for other purposes	Per Head for all purposes	Unaccounted for
January	6,298	14·0			14·0		150,323				150·3	
February	3,500	7·8			7·8		149,643				149·6	
March	5,000	11·1			11·1		141,290				141·3	
April	3,367	7·5			7·5		137,500				137·5	
May	6,440	14·3			14·3		131,290				131·3	
June	3,417	7·6			7·6		140,333				140·3	
July	5,056	11·2			11·2		160,323				160·3	
Aug	6,790	15·1			15·1		184,516				184·5	
September	3,375	7·5			7·5		170,167				170·2	
October	3,161	7·0			7·0		155,484				155·5	
November	6,167	13·7			13·7		169,333				169·3	
December	7,677	17·1			17·1		165,000				165·0	
Average for the year	5,021	11·2			11·2		154,600				154·6	

Month	Edmonton—Population 65,000						Lethbridge—Population 12,000					
January	5,969,032	53·3	22·9	15·6	91·8		1,208,806	49·5	51·2		100·7	
February	6,185,714	55·2	23·8	16·2	95·2		1,145,536	63·3	32·1		95·4	
March	6,070,323	54·2	23·3	15·9	93·4		1,134,355	65·0	29·5		94·5	
April	6,277,667	56·0	24·2	16·4	96·6		1,167,567	66·2	30·9	0·2	97·3	
May	6,213,226	55·4	23·9	16·3	95·6		1,199,194	66·0	33·9		99·9	
June	6,596,333	58·9	25·4	17·2	101·5		1,404,267	78·9	37·2	0·9	117·0	
July	6,355,484	56·8	24·4	16·6	97·8		1,590,774	90·5	38·0	4·0	132·5	
August	6,651,935	59·3	25·6	17·4	102·3		1,498,194	82·2	40·2	2·4	124·8	
September	5,985,333	53·4	23·0	15·7	92·1		1,272,667	69·6	36·5		106·1	
October	5,585,484	49·8	21·5	14·6	85·9		1,246,065	73·1	30·7		103·8	
November	5,996,000	53·5	23·1	15·7	92·3		1,363,533	74·1	39·5		113·6	
December	6,200,968	55·3	23·9	16·2	95·4		1,288,806	72·9	34·5		107·4	
Average for the year	6,173,958	55·1	23·8	16·1	95·0		1,293,314	71·0	36·2	0·6	107·8	

Month	Medicine Hat—Population 10,000						Redcliff—Population 1,000					
January	2,147,419				214·7		134,024				134·0	
February	2,168,214				216·8		149,330				149·3	
March	2,115,484				211·5		138,992				139·0	
April	2,250,333				225·0		140,536				140·5	
May	2,464,516				246·5		138,825				138·8	
June	3,244,000				324·4		137,033				137·0	
July	3,408,710				340·9		174,895				174·9	
August	3,325,161				332·5		173,968				174·0	
September	2,733,333				273·3		172,683				172·7	
October	2,673,226				267·3		159,427				159·4	
November	2,533,000				253·3		161,283				161·3	
December	2,366,129				236·6		135,847				135·8	
Average for the year	2,619,127				261·9		151,404				151·4	

Cities and Towns in the Province of Alberta—Record of Average Daily Water Consumption in Imperial Gallons for years 1915-1927 (inclusive)

Average for Year	Per Head Domestic	Per Head Industrial	Per Head other purposes	Per Head all purposes	Unaccounted for	Per Head Domestic	Per Head Industrial	Per Head other purposes	Per Head all purposes	Unaccounted for
	Edmonton					Lethbridge				
1915	46·0	31·0	3·0	80·0		81·4	32·2	1·5	115·1	
1916	52·5	20·7	5·7	78·9		116·0	41·3	0·7	158·0	
1917	56·3	25·0	9·7	91·0		95·0	55·0		150·0	
1918	58·0	26·2	10·1	94·3		102·2	44·7	3·0	149·9	
1919	56·7	24·6	9·7	91·7		78·1	26·9		107·3	
1920	54·7	23·4	16·2	94·3		91·8	35·1	*6·8	129·1	
1921	54·6	23·4	16·8	94·8		94·2	27·8	1·4	123·4	
1922	62·2	24·9	24·1	111·1		110·8	33·5		145·1	
1923	53·5	22·4	13·5	89·4		96·0	35·4	0·7	132·1	
1924	55·0	23·7	15·7	94·4		88·8	36·8	1·4	127·0	
1925	54·1	23·3	15·8	93·2		74·7	35·0	0·8	110·5	
1926	54·0	23·2	15·8	93·0		76·6	36·8	1·5	114·9	
1927	55·1	23·8	16·1	95·0		71·0	36·2	0·6	107·8	
	Bassano					Carmangay				
1915	6·5	60·2		66·7		41·9		2·0	43·9	
1916						32·6			32·6	
1917	17·9	154·3	95·4	267·6		31·3			31·3	
1918				211·0		29·8		1·0	30·8	
1919				194·7		32·5		1·2	33·7	
1920				158·9		26·2		†3·4	30·3	
1921				137·8						
1922				135·7						
1923				150·8				No records		
1924				176·8						
1925				178·0						
1926				174·4						
1927				154·6						
	Medicine Hat					Redcliff				
1915	181·0	28·0	15·0	224·0		31·1	6·8		37·9	
1916				214·0		36·8	22·1	1·0	59·9	
1917				257·0		42·5	30·3		72·8	
1918				264·0		66·4	22·4		88·8	
1919				234·0		79·1	13·7		92·8	
1920				206·8		67·9	16·2		84·2	
1921				175·3		65·7	9·6	0·5	75·8	
1922				187·9		97·9	7·8		105·6	
1923				213·4		82·9	8·1		‡91·0	
1924				222·2		136·6	8·4		145·0	
1925				252·3					143·4	
1926				265·7					176·2	
1927				261·9					151·4	
	Athabaska									
1915						14·3			14·3	
1916						10·9			10·9	
1917						24·0			24·0	
1918						27·6			27·6	
1919						26·1			26·1	
1920						44·3			44·3	
1921						33·3			33·3	
1922										
1923										
1924						18·0		0·2	18·2	
1925						19·1			19·1	
1926						7·5			7·5	
1927						11·2			11·2	

*4 months. †7 months. ‡Based on 4 months' records.

Cities and Towns in the Province of Saskatchewan—Record of Daily Water Consumption in Imperial Gallons for the year 1927

Estevan—Population 2,500

Month	Daily Average for the month	Per Head for domestic purposes	Per Head for industrial purposes	Per Head for other purposes	Per Head for all purposes	Unaccounted for
January	55,863	....	....	....	22·3	....
February	62,250	....	....	....	24·9	....
March	53,315	....	....	....	21·3	....
April	43,475	....	....	....	17·4	....
May	44,661	....	....	....	17·9	....
June	63,275	....	....	....	25·3	....
July	71,113	....	....	....	28·4	....
August	61,137	....	....	....	24·5	....
September	65,275	....	....	....	26·1	....
October	81,629	....	....	....	32·6	....
November	85,750	....	....	....	34·3	....
December	70,452	....	....	....	28·2	....
Average for the year	63,183	....	....	....	25·3	....

Moose Jaw—Population 21,000

Month	Daily average for the month	Per Head for domestic purposes	Per Head for industrial purposes	Per Head for other purposes	Per Head for all purposes	Unaccounted for
January	969,903	25·1	21·1	....	46·2	....
February	994,607	30·8	16·5	....	47·3	....
March	1,131,839	36·5	17·4	....	53·9	....
April	1,147,300	37·7	16·9	....	54·6	....
May	1,085,000	35·8	15·9	....	51·7	....
June	1,092,000	33·6	18·4	....	52·0	....
July	1,301,774	37·7	24·3	....	62·0	....
August	1,261,097	39·2	20·8	....	60·0	....
September	1,027,967	27·6	21·3	....	48·9	....
October	950,645	25·7	19·6	....	45·3	....
November	958,800	24·8	20·9	....	45·7	....
December	968,968	28·3	17·8	....	46·1	....
Average for the year	1,074,158	31·9	19·2	....	51·1	....

Weyburn—Population 4,000

Month	Daily Average for the month	Per Head for domestic purposes	Per Head for industrial purposes	Per Head for other purposes	Per Head for all purposes	Unaccounted for
January	209,527	52·4	....	....	52·4	....
February	232,187	58·0	....	....	58·0	....
March	245,166	61·3	....	....	61·3	....
April	224,713	56·2	....	....	56·2	....
May	235,932	59·0	....	....	59·0	....
June	263,329	65·8	....	....	65·8	....
July	289,029	72·3	....	....	72·3	....
August	318,115	79·5	....	....	79·5	....
September	300,646	75·2	....	....	75·2	....
October	293,955	73·5	....	....	73·5	....
November	277,985	69·5	....	....	69·5	....
December	276,388	69·1	....	....	69·1	....
Average for the year	263,914	66·0	....	....	66·0	....

Prince Albert—Population 8,000

Month	Daily average for the month	Per Head for domestic purposes	Per Head for industrial purposes	Per Head for other purposes	Per Head for all purposes	Unaccounted for
January	565,968	29·4	31·5	0·4	70·7	9·4
February	646,675	30·5	31·5	0·3	80·8	18·5
March	573,939	27·9	25·4	0·3	71·7	18·1
April	505,827	30·4	26·9	1·1	63·2	4·8
May	602,519	27·1	26·1	1·7	75·3	20·4
June	662,133	29·1	36·6	2·8	82·8	14·3
July	673,045	25·5	34·0	2·3	84·1	22·3
August	673,161	27·7	40·1	2·3	84·1	14·0
September	663,397	28·6	41·4	2·5	82·9	10·4
October	548,890	28·6	26·0	2·4	68·6	11·6
November	546,917	26·7	29·3	1·6	68·4	10·8
December	551,245	30·8	30·0	0·4	68·9	7·7
Average for the year	601,143	28·5	31·6	1·5	75·1	13·5

North Battleford—Population 5,100

Month	Daily Average for the month	Per Head for domestic purposes	Per Head for industrial purposes	Per Head for other purposes	Per Head for all purposes	Unaccounted for
January	146,629	8·9	1·3	4·0	28·7	14·5
February	167,911	10·0	0·8	6·2	32·9	15·9
March	182,503	8·6	0·6	4·4	35·8	22·2
April	77,361	9·4	0·8	4·3	15·2	0·7
May	184,466	10·8	0·9	5·2	36·2	19·3
June	178,703	9·9	0·9	4·7	35·0	19·5
July	160,110	9·5	1·0	2·4	31·4	18·5
August	181,132	10·8	1·1	3·9	35·5	19·7
September	128,738	16·3	1·2	2·2	25·2	5·5
October	133,529	10·5	0·9	3·9	26·2	10·9
November	114,110	12·6	0·9	2·6	22·4	6·3
December	135,402	11·4	0·8	5·1	26·5	9·2
Average for the year	149,216	10·7	0·9	4·1	29·2	13·5

Kamsack—Population *375

Month	Daily average for the month	Per Head for domestic purposes	Per Head for industrial purposes	Per Head for other purposes	Per Head for all purposes	Unaccounted for
January	114,845	22·3	202·4	0·3	306·3	81·3
February	118,811	26·9	201·2	2·6	316·8	86·1
March	111,042	27·2	175·8	3·6	296·1	89·5
April	120,767	24·6	172·3	0·6	322·1	124·6
May	120,619	24·9	186·2	2·6	321·7	108·0
June	113,057	30·0	124·2	0·7	301·5	146·6
July	115,455	38·4	111·0	0·1	307·9	158·4
August	104,968	36·1	103·5	0·8	279·9	139·5
September	110,732	35·5	124·5	0·4	295·3	134·9
October	132,223	27·9	197·7	2·3	352·6	124·7
November	177,160	28·8	312·7	0·4	472·4	130·5
December	183,752	29·4	339·9	5·3	490·0	115·4
Average for the year	126,953	29·3	187·6	1·6	338·5	120·0

Regina—Population 37,100

Month	Daily Average for the month	Per Head for domestic purposes	Per Head for industrial purposes	Per Head for other purposes	Per Head for all purposes	Unaccounted for
January	2,954,161	72·0	5·4	2·2	79·6	....
February	3,040,411	74·4	4·3	3·2	81·9	....
March	3,024,697	75·1	4·4	2·0	81·5	....
April	2,782,143	69·6	3·8	1·6	75·0	....
May	2,799,155	70·1	4·4	0·9	75·4	....
June	2,994,793	73·7	5·5	1·5	80·7	....
July	2,768,987	64·0	9·4	1·2	74·6	....
August	3,085,316	68·2	11·8	3·2	83·2	....
September	2,918,127	66·8	10·6	1·3	78·7	....
October	2,973,110	72·8	5·9	1·4	80·1	....
November	3,098,113	75·2	6·5	1·8	83·5	....
December	2,984,100	73·3	5·4	1·7	80·4	....
Average for the year	2,951,926	71·3	6·5	1·8	79·6	....

Saskatoon—Population 31,200

Month	Daily average for the month	Per Head for domestic purposes	Per Head for industrial purposes	Per Head for other purposes	Per Head for all purposes	Unaccounted for
January	1,934,134					†
February	2,013,750	28·8	15·4	0·7	63·1	18·2
March	1,963,387					
April	2,195,500					
May	2,428,387	27·5	16·5	1·6	79·2	33·6
June	2,789,333					
July	2,722,581					
August	2,696,452	26·1	19·6	6·6	84·2	31·9
September	2,457,000					
October	2,448,710					
November	2,466,667	30·5	25·1	1·2	78·6	21·8
December	2,439,355					
Average for the year	2,379,610	28·2	19·2	2·5	76·3	26·4

*Only 75 consumers or approx. 375 persons supplied. This figure is used in computations although total population is about 2,000.

†Includes Town of Sutherland.

Cities and Towns in the Province of Saskatchewan—Record of Average Daily Water Consumption in Imperial Gallons for Years 1915-1927 (inclusive)

Average for Year	Per Head Domestic	Per Head Industrial	Per Head other purposes	Per Head all purposes	Unaccounted for	Per Head Domestic	Per Head Industrial	Per Head other purposes	Per Head all purposes	Unaccounted for	Per Head Domestic	Per Head Industrial	Per Head other purposes	Per Head all purposes	Unaccounted for
	Regina					Saskatoon					Moose Jaw				
1915	55·0	7·5	0·1	62·6	......	21·6	13·9	2·2	45·6	7·9	24·1	4·6	......	28·7	......
1916	66·1	7·8	......	73·9	......	21·0	15·4	1·9	52·6	14·3	35·2	12·3	......	47·5	......
1917	59·2	12·6	0·3	72·1	......	24·4	15·6	5·8	66·4	20·6	45·8	13·1	......	58·9	......
1918	56·9	11·1	0·1	68·1	......	27·1	17·2	2·4	63·1	16·4	31·6	15·4	......	47·0	......
1919	42·8	8·3	......	51·2	......	28·0	16·3	1·9	64·1	17·9	24·8	15·1	......	39·9	......
1920	48·9	9·1	0·9*	58·8	......	29·4	14·3	6·1	74·1	24·4	24·5	14·5	......	39·1	......
1921	49·6	10·1	2·1	62·6	0·8	29·5	20·3	1·1	72·1	21·2	30·9	3·9	6·2	41·0	......
1922	59·2	12·6	2·5	74·5	......	31·0	23·6	1·5	78·4	22·4	34·8	9·0	......	43·8	......
1923	61·7	14·5	2·0	78·2	......	28·8	20·8	1·5	71·0	23·1	34·9	9·4	......	44·3	......
1924	65·1	9·7	1·5	76·7	0·4	27·9	19·2	2·4	69·3	19·8	36·5	8·0	......	44·5	......
1925	72·1	4·4	1·5	78·0	......	31·4	20·5	3·0	81·0	26·1	33·0	9·7	......	42·7	......
1926	72·0	4·8	1·4	78·2	......	29·5	17·8	2·8	73·0	22·9	33·1	14·3	......	47·4	......
1927	71·3	6·5	1·8	79·6	......	28·2	19·2	2·5	76·3	26·4	31·9	19·2	......	51·1	......

Average for Year	Per Head Domestic	Per Head Industrial	Per Head other purposes	Per Head all purposes	Unaccounted for	Per Head Domestic	Per Head Industrial	Per Head other purposes	Per Head all purposes	Unaccounted for	Per Head Domestic	Per Head Industrial	Per Head other purposes	Per Head all purposes	Unaccounted for
	North Battleford					Weyburn					Kindersley				
1915	6·6	1·3	2·7	14·8	4·2	17·4	......	0·4	17·8	......	4·9	8·4	1·6	14·9	......
1916	9·5	2·0	4·9	22·7	6·3	16·9	......	0·3	17·2	......	5·5	26·8	......	32·3	......
1917	10·2	2·2	4·0	23·1	6·7	30·1	......	......	30·1	......	5·8	44·4	......	50·2	......
1918	10·0	4·8	3·0	26·3	8·5	26·4	......	......	26·4	......	6·0	8·9	......	14·9	......
1919	11·5	1·6	4·4	29·7	12·2	25·5	......	......	25·5	......	7·8	......	......	7·8	......
1920	11·3	5·8	5·9	34·0	10·9	30·2	......	......	30·2	......	6·9	17·5	......	21·5	......
1921	9·7	2·8	2·9	26·7	11·3	27·1	......	......	27·1	......	8·5	11·0	......	19·5	......
1922	11·0	2·8	4·3	34·1	15·9	......	......	......	64·4	......	10·1	12·3	......	22·4	......
1923	11·3	1·6	4·4	25·0	7·7	......	......	......	68·0	......	11·5	......	......	11·5	......
1924	10·8	2·3	3·7	33·4	16·6	......	......	......	77·4	......	11·0	......	......	11·0	......
1925	11·0	1·8	4·9	31·8	14·1	......	......	......	64·1	......	6·4	......	......	6·4	......
1926	11·7	2·3	3·3	30·9	13·6	61·8	......	......	61·8	......	10·0	......	......	10·0	......
1927	10·7	0·9	4·1	29·2	13·5	66·0	......	......	66·0	......	......	......	......	......	......

Average for Year	Per Head Domestic	Per Head Industrial	Per Head other purposes	Per Head all purposes	Unaccounted for	Per Head Domestic	Per Head Industrial	Per Head other purposes	Per Head all purposes	Unaccounted for	Per Head Domestic	Per Head Industrial	Per Head other purposes	Per Head all purposes	Unaccounted for
	Kamsack					Prince Albert					Estevan				
1915	......	......	......	......	......	......	......	......	......	......	9·5	7·1	1·5	18·1	......
1916	......	......	......	......	......	......	......	......	......	......	8·2	5·7	1·0	14·9	......
1917	......	......	......	......	......	......	......	......	......	......	9·7	5·5	4·3	19·5	......
1918	31·6	66·3	......	97·9	......	......	......	......	......	......	9·3	0·7	7·2	17·2	......
1919	......	......	......	......	......	......	......	......	......	......	9·6	2·9	......	12·5	......
1920	......	......	......	......	......	......	......	......	......	......	9·3	4·4	......	13·7	......
1921	50·4	724·9	......	775·3	......	......	......	......	83·0	......	6·1	4·7	2·0	12·8	......
1922	50·3	690·2	......	740·6	......	20·4	23·2	1·9	69·6	20·1	8·5	6·4	2·9	17·9	......
1923	27·3	291·5	......	478·5	......	22·8	27·1	1·6	70·0	18·5	8·6	10·8	1·4	20·3	......
1924	24·8	194·4	......	394·2	......	24·2	28·7	1·5	65·4	11·0	9·2	6·1	2·9	18·2	......
1925	23·3	190·6	......	405·5	......	29·2	30·2	1·3	70·6	9·9	......	......	......	16·8	......
1926	26·5	177·5	6·4	334·8	133·4	28·4	31·5	1·0	69·4	8·5	......	......	......	20·1	......
1927	29·3	187·6	1·6	338·5	120·0	28·5	31·6	1·5	75·1	13·5	......	......	......	25·3	......

*10 months.

General River Control

Due to the abnormal precipitation during the fall of 1926 and spring of 1927 most of the streams and lakes in Alberta rose to extremely high stages, flooding the lower lying lands and in many cases causing much damage. Field investigations were made during 1927-28 in a number of such cases where complaints were made to the Department.

Sturgeon River.—Settlers have made complaints for a number of years regarding the flooding of the lower lying lands along the Sturgeon river principally in the vicinity of Big lake and lake St. Ann.

At Alberta Beach, a summer resort on lake St. Ann, the lake ice during the early spring of 1927 was driven on shore by the winds piling up in places to a height of ten feet and damaging a number of cottages on low lying lots to the north of the beach. At Big lake and other low-lying points along the river large areas of hay lands were submerged.

In an endeavour to find a practical method of lessening the danger of flooding and to gain a good general knowledge of the character of the Sturgeon river a canoe reconnaissance of some 160 miles of the river between lake St. Ann and the Saskatchewan river was made in co-operation with the Dominion Public Works Department. The reconnaissance showed that before any comprehensive scheme of river control could be planned it would be necessary to make detailed surveys of 40 or 50 miles of the river channel in addition to the surveys already made in connection with a proposed drainage scheme for the reclamation of lands in Big lake. Since the drainage of Big lake alone, which would constitute only a portion of a comprehensive regulation scheme, has been estimated to cost at least $220,000, it is evident that to regulate the Sturgeon River flow would require a much greater expenditure than the benefits derived would justify.

Bow River.—Several ice jams along the Bow river in the vicinity of Calgary during the winter of 1927-28 caused the river to overflow its banks with resultant damage to property.

The worst flood occurred on November 16 when the flood wave caused by breaking of an ice-jam passed through the city of Calgary damaging the city pump-house and causing a further jam at the Calgary Water Power Company's dam, flooding sections of the Broadview and Westmount districts in Hillhurst. The river rose about ten feet, filling many basements and threatening foundations.

From an investigation made this flood appears to have been caused by slush ice and snow which accumulated at a point some distance above Calgary. Near Bowness the ice collected forming a jam which gradually grew in size for about thirty-six hours and then broke rushing down in a wave and carrying along the accumulation of ice cakes from the shores.

At the Eau Claire Lumber Company's plant about two million feet of logs were carried away by the flood. The canal leading to the Calgary Water Power Company's power-house was completely filled up with ice and a structure erected just above the company's dam for obtaining gravel from the river was practically destroyed.

Cascade River.—An ice-jam occurred on the Cascade river about December 20 near Anthracite causing flooding on the lower lying lands in this vicinity. From an investigation at the time it was found that the jam had formed at some distance above the Tunnel Mountain Drive bridge. This is the same point where similar trouble occurred in 1922 and again in 1926. The river has a wide bed above the point where the trouble occurs and a slow current, but at the immediate point where the jam occurs the river rises sufficiently to overflow the bank. It was found that nothing could be done to relieve the situation which only lasted for a short time and then cleared itself.

Highwood River.—A stretch of some 4 miles of the Highwood river through range 29 in the vicinity of the town of High River periodically overflows its banks, some of this flow returning to the river through Baker creek which parallels the river at this section and a portion finding its way to the Little Bow river which heads practically on the bank of the Highwood river in the above range.

In the year 1917 a very bad break occurred in the river bank in the S.E. $\frac{1}{4}$, sec. 32, tp. 18, rge. 29, at a sharp bend of the river. This break threatened to permanently change the course of the Highwood river into the channel of the Little Bow river, thus injuriously affecting water rights granted from the Bow river of which the Highwood is an important tributary.

Suitable work designed to maintain the Highwood river in its proper channel were accordingly built by this department. These works successfully withstood subsequent floods until the year 1923. In that year, due to unprecedented high water, they were partly washed out but were immediately repaired by this department in co-operation with the provincial Public Works Department. Since that time other protection works have been constructed by the town of High River, assisted by the Dominion and provincial Public Works Departments, at a point just above the railway bridge at the town. During the year 1927-28 the river cut into its banks at two points, one near the power-house in the town of High River and the other some 3 miles above the town in sec. 33, tp. 18, rge. 29. At the lower point the river is on the point of cutting through to an old river channel which circles the park thus threatening to damage a portion of the residential and business sections of the town situated on the west side of the railway. There is, however, not much danger of the river getting into the Little Bow channel at this point. At the upper point the river not only cut away a large section of the river bank but overflowed to Baker creek. The heavy brush at this location has thus far prevented the overflow from cutting a channel but any flood of a few days duration would cut a channel to Baker creek when it would be only a matter of time till it again cut through to the Little Bow river.

This Department in co-operation with the Dominion and provincial Public Works Departments has made a number of investigations and surveys of the river at the points threatened and it is probable that some joint action will be taken.

Wabamun Lake.—Wabamun lake situated on the main line of the Canadian National Railways some 40 miles west of Edmonton has for some years been used as a pleasure and health resort, mainly by the people of Edmonton and along a number of the beaches such as Seba, Fallis, Wabamun and Kapasawin summer cottages have been built, in some cases on the lower lying lots along the lake.

Wabamun Creek.—At the northeast end of the lake and on the Alexis Indian reserve is the natural outlet to the lake, and through a very tortuous channel finally empties into the Saskatchewan river in tp. 51, rge. 3, W. 4th mer. At a point about three-quarters of a mile from the outlet this creek makes a bend toward the lake and comes within about 100 feet of the shore.

Some time during the year 1912 one of the settlers whose lands on the lake shore were flooded, cut a new channel from the lake across this narrow neck of land with the result that the sudden rush of water through the new outlet scoured out a large channel and seriously affected the natural water level of the lake. Although the artificial outlet was later temporarily filled in by interested parties its existence has been the cause for complaints by property owners along the lake. While it was generally agreed that some rgulating works should be constructed in the artificial outlet various factions could not agree upon the ele-

vation at which the lake should be maintained. Cottage owners at such points as Wabamun where low-water conditions uncovered the unsightly mud flats desired a high level, others on the lower lying lots desired a fairly low level, while owners of hay lands advocated a lower level still.

This controversy was brought to a successful conclusion by a representative meeting of property owners which agreed on a water level of 2372·1 feet. The Dominion Public Works Department undertook to construct regulation works provided application was made by one or more of the municipalities affected accompanied by an undertaking to assume all responsibility for damage claims.

The village of Wabamun was authorized by this Department to construct the necessary works under the above provisions and the works have since been constructed at the expense of the Dominion Public Works Department in accordance with plans approved by this Department.

Major Irrigation Projects

THE CANADIAN PACIFIC RAILWAY COMPANY

Western Section.—This project diverts water from the Bow river in Sec. 13, tp. 24, rge. 1, W. 5th mer., just east of the city of Calgary, and has been in operation for 20 years. At the close of the year 1927 there were 202,096 acres held under water agreement as compared with 203,184 acres in 1926, a decrease of 1,088 acres. The number of water users was 352 as compared with 813 in 1926.

Water was turned into the system on May 23 and the headgates closed on October 1. During the past season's operations 50,848 acre-feet of water were diverted from the Bow river. The highest daily discharge recorded was 738 on September 23 and the average daily flow for the month of maximum demand was 238 cubic feet per second during August.

During the past season 1,273 acres were actually irrigated, a decrease under 1926 of some 18,288 acres. The total cropped irrigable area was 203,000 acres producing $5,090,100 based on the company's unit values or representing a per acre return of $25. Of the total cropped area on water-right land 150,000 acres were in wheat which produced 4,500,000 bushels or at the rate of 30 bushels per acre. Other crops on water-right lands included, oats 23,600 acres, barley 5,000 acres, hay crops 16,300 acres.

The season was exceptionally favourable for crop growth, the total precipitation for the year being 4 inches greater than the average of 13 years. The rainfall for May, June and July was well over the average. Elctrical storms were numerous in June and July and on many occasions were accompanied by hail which did considerable damage. The fall weather was wet and cold and winter set in early in November, zero weather continuing until the end of the year.

The period free from killing frosts covered 128 days from May 9 to September 15, or 5 days shorter than in 1926. The total precipitation recorded at the Canadian Pacific Railway Company's operating headquarters at Strathmore for the year was 17·78 inches, of which 13·43 inches were received between May 1-September 30.

A fairly extensive maintenance program was again undertaken during the past season and included the following:—

115 miles of ditches cleared out by mechanical excavators.
5½ miles of ditches cleared out by team work.
249 timber structures repaired.
3 concrete structures repaired.
638 timber structures renewed.
43 new timber structures.

The estimated total yardage moved during the season was 179,200, of which 92,000 was done by excavator, 50,400 by drag line and 36,800 by team. Of the lumber used in renewals approximately 14 per cent was creosoted.

The live stock situation was very little changed from the previous season. Prices for cattle and sheep were a little higher and for hogs slightly lower than 1926. The cropped area of the project was also increased by the breaking up of some 15,400 acres of new land.

Eastern Section.—This project diverts water from the Bow river at the Horseshoe Bend dam on the Blackfoot Indian reserve in tp. 21, rge. 19, W. 4th mer. and has been in operation for 14 years. At the close of the year 1927, 69,690 acres were held under water agreement as compared with 84,847 acres in 1926. The number of water users was 578 as compared with 638 in the preceding year.

Water was turned into the system on May 17 and the headgates closed on October 1. During the past season's operations 213,000 acre-feet of water were diverted from the Bow river. The highest daily discharge recorded was 1,050 on August 20 and the average daily flow for the month of maximum demand was 1,030 cubic feet per second during August.

During the past season 7,921 acres were actually irrigated, a decrease under 1926 of some 66,480 acres. The total cropped irrigable area was 66,640 acres, which produced crop values amounting to $1,821,680 based on the company's unit values, or representing a per acre return of $27.30. On the irrigated lands the area in wheat was 31,967 acres which produced 904,751 bushels or at the rate of 28·3 bushels per acre. Other staple crops grown included—oats 9,025 acres yielding 44·3 bushels per acre, barley 4,185 acres yielding 40·2 bushels per acre, alfalfa 4,720 acres yielding 1·8 tons per acre.

The season was on the whole very favourable for crop growth. Exceptionally high precipitation and very low evaporation losses were recorded, an unusual condition in this area. The total precipitation recorded at the Canadian Pacific Railway Company's operating headquarters at Brooks for the 12 months was 20·06 inches. The seasonal precipitation in inches as recorded at the Dominion Experimental Station 2 miles west of Brooks is as follows:—April 2·13, May 4·41, June 3·76, July 2·61, August 1·09, September 1·74, October 0·73, or equal to 16·47 inches.

The Grimm Alfalfa Seed Growers Association which was incorporated in 1924 had an unsatisfactory year owing to unfavourable weather conditions. From 1,040 acres of irrigable land 478 bushels of alfalfa seed were harvested or at the rate of 0·5 bushels per acre.

Railway transportation facilities for the settlers on this project have been greatly improved during the past year. Two branch lines have been constructed, one to serve the territory lying south of the main transcontinental line and the other the area lying north of the Bassano-Express line. *Lethbridge Section.*—This project diverts its water from the St. Mary river, the headworks being located in sec. 36, tp. 1, rge. 25, w. 4th mer., 6 miles north of the international boundary and has been in operation for 28 years. At the close of the year there were 72,742 acres held under water agreement as compared with 73,993 acres in 1926. Two newly constructed irrigation districts have contracts with the company for the supply of water for 11,465 irrigable acres, made up as follows:—Magrath Irrigation district 5,024 acres, Raymond Irrigation district 6,441 acres. The total irrigable area now being served by these works is, therefore, 84,207 acres. The number of water users was 349 as compared with 841 in 1926.

Water was turned into the system on April 26 and the headgates closed on October 31. During the period under operation 123,000 acre-feet of water were diverted from the St. Mary river. The highest daily discharge recorded was 559 on August 10 and the average daily flow for the month of maximum demand was

501 cubic feet per second during August. The area which received water during the season was 21,600 acres, the actual cropped area was 64,375 which produced values amounting to $2,147,767 based on the company's unit values, or representing a per acre return of $33.36. The major crop was wheat which represented 47·5 per cent of the cropped area and produced an average yield of 32·3 bushels per acre valued at $1,138,563.

The period free from damaging frosts extended from May 9 to September 26, or equal to 140 days as compared with 132 days in 1926. The total precipitation recorded at Lethbridge during the year was 23·85 inches and the seasonal precipitation 17·36 inches. The average monthly precipitation at Lethbridge for the past 26 years was as follows:—January 0·63, February 0·68, March 0·69, April 0·95, May 2·58, June 2·77, July 1·81, August 1·75, September 1·82, October 0·83, November 0·68, December 0·63.

Spring conditions were very backward, the month of May being cold and wet with a precipitation 5 inches above normal. The months following were colder than usual and the total precipitation for the year exceeded the average by over 8 inches. Winter conditions set in early in November with very low temperatures up to the end of the year.

The maintenance program included:—

14·3 miles of ditches cleared out by mechanical excavators, representing some 30,000 cu. yds. of material.

42 timber structures repaired.

Improvements to the embankment at the west end of the Kimball headworks.

Rebuilding and improving controlled drop in Pothole channel in SW. ¼ sec. 9, tp. 22, rge. 5, W. 4th mer.

The live stock situation has shown little change, there having been a slight increase in the number of hogs and sheep and a slight decrease in other stock.

Taber Irrigation District

This district receives its water supply from the St. Mary river through the works of the Alberta Railway and Irrigation Company, previously referred to as the Canadian Pacific Railway Company's Lethbridge Section. The 1927 operating season was the seventh since construction. By change of content duly approved and promulgated in the *Alberta Gazette* of January 31, 1928, the district is authorized to add 4,662 irrigable acres to their system, bringing the total area up to 21,601 acres. Some minor amendments to the Irrigation Districts Act are now before the provincial legislature and if passed will empower irrigation districts to increase their bonded indebtedness to provide for enlargements and changes to their systems. As soon as these changes receive legislative approval the district will proceed to vote on the necessary by-law to enable them to finance the additional works. The number of water users in the district prior to the change of content was 161, the area irrigated during the season being 576 acres.

Water was turned into the system on June 20 and the headgates closed for the season on November 5, some 6,280 acre-feet of water being diverted from the Chin Coulee Storage reservoir. The highest daily discharge recorded was 51 cubic feet per second on August 1 and 13, and the average daily flow for August, the month of maximum use, was 33·6 cubic feet per second.

The principal crop was again wheat which represented approximately 50 per cent of the cropped area on irrigable land. The sugar beet area was 1,630 acres, an increase over 1926 of 847 acres, the average yield was 8 tons per acre

and the saccharine content averaged 17·8 per cent. The district has been fortunate in having to use very little water for irrigation, the precipitation received and the moisture already stored in the land being adequate to grow a very satisfactory crop.

Unfortunately weather conditions in the fall prevented threshing of grain crops and approximately 60 per cent of the grain has remained in the stook throughout the winter. Accurate returns regarding yields are, therefore, not available.

Canada Land and Irrigation Company

This project diverts its water from the Bow river in sec. 31, tp. 21, rge. 25, w. of 4th mer.

Due to the wet season very little water was used for irrigation and the work in connection with operating the system was less than in any previous year of the company's history.

Diversions from the Bow river to Lake McGregor reservoir were made from September 14 to November 7, a total of 12,100 acre-feet being diverted. Earlier diversion to supplement the storage in lake McGregor was prevented by the re-construction of flume number 2 on the main canal which was destroyed in 1926. The storage in the Little Bow reservoir was sufficient to take care of water demands for all purposes during the year. At the close of the season there were 11,250 acre-feet in storage at the Little Bow reservoir and 82,500 acre-feet in lake McGregor. During the year the company has carried out a fairly extensive program of maintenance and new construction. On the main canal 7 new bridges and 1 flume have been built as replacements. Repairs have been made to many old structures and some 3¼ miles of ditches have been cleaned out. On the lateral system 8·8 miles of new laterals were built and 75 small structures completed. Preparations were under way at the close of the season and will be continued in the spring of 1928 for the completion of a lateral system to serve a gross area of some 34,000 acres.

Land sales during the calendar year 1927 have been satisfactory, the company having disposed of 6,877 acres, of which 5,617 were irrigable. The total area now being served by the system is 27,336 acres, of which 4,501 is in the New West irrigation district and including 152 acres of privately owned land served through the works. During the past two years most of the land was purchased under the company's crop share agreement and owing to an exceptionally favourable season these purchasers were able to complete their first payments with interest and water rental out of their first crop.

The area actually irrigated was 700 acres, representing 4 per cent of the developed irrigable area and the average per acre return from the irrigated land was $29.66, based on the company's unit values as compared with $29.01 in 1926 and $30.66 in 1925. The estimated gross value of produce and live stock shipped out during the year exceeds $500,000.

New West Irrigation District

The water supply of this district is obtained from the Bow river through the works of the Canada Land and Irrigation Company. The point of diversion from the company's main canal being in the NE. ¼ sec. 36, tp. 13, rge. 17, w. 4th mer. The district contains an irrigable area of 4,501 acres and has 26 water users. The area irrigated in 1927 was 151 acres as compared with 3,426 in 1926. A generous rainfall was received throughout the district during the growing season and crops were produced with but little if any irrigation and yielded considerable above average. During the period May 1 to August 31, a total of 16·75 inches of precipitation was recorded.

The major crop was again wheat which represented some 58 per cent of the total irrigable area and yielded an average of 30·1 bushels per acre as compared with 21·4 bushels in 1926. Other crops included oats, barley, alfalfa, flax and green feed.

The bonded indebtedness at the close of the year was $209,500, the amount expended on repairs $394.55 and the total cost of management $1,907.80. This district is gradually getting established and is in a sound financial position.

At the beginning of the season an automatic gauge was installed at the point where the district's canal diverts from the company's main canal. This should greatly increase the accuracy of the records of water delivered to the district and also save the district's watermaster a great deal of time.

The maintenance program included back-filling structures, bank protection around structures and grading up low embankments.

Small streams of water were delivered throughout the season for stock-watering purposes and a little water was used on alfalfa and some late crops.

A campaign against the weed menace on canal rights of way was started and good progress made. The most noxious weeds were sprayed with a solution of blue stone (copper sulphate) and water, with very satisfactory results.

Owing to early snowfalls and extremely cold weather a proportion of the crop remained in the stooks at the end of the year awaiting favourable threshing weather.

Lethbridge Northern Irrigation District

The district diverts its water from the Oldman river at a point in the Peigan Indian reserve about the centre of tp. 8, rge. 27, w. 4th mer.

The total classified irrigable area as at the close of 1927 was 103,238 acres, of which 10,012 were irrigated during the past season as compared with 56,395 in 1926. The 1927 operating season was the fourth since construction and although a much smaller area was irrigated owing to the favourable weather conditions which prevailed, crop returns were equally satisfactory. Weather conditions in the fall of the year were, however, far from satisfactory and serious delays have been caused to threshing operations and the haulage of grain to elevators. The major crop was wheat, 1,997,785 bushels being produced from 60,161 acres, equal to an average yield of 33·7 bushels. This area represented 77 per cent of the farmed irrigable land.

The rate charged per irrigable acre for 1927 was $3.75 and it is anticipated that, owing to the surplus on hand to meet debenture charges, the 1928 payments may be still further reduced. In 1929, however, payments into the sinking fund commence and the Official Trustee has drawn attention to the fact that the water right payments must then be increased to $4.65 or thereabouts and continue at that figure during the life of the debentures.

Good progress was again made by the colonization organization and during the year 86 families were settled on the vacant lands of the project. At the close of the year there were 737 water users as compared with 646 in 1926; of this number 558 actually used water.

The past year has been one of the best crop years ever experienced in this part of southern Alberta. An exceptionally high rainfall in May carried the crops through until the end of June when further precipitation in July and August carried the crop to maturity. In a few localities where lighter soils prevail a light irrigation at the end of June would have increased yields. Much of the crop was seeded later than usual owing to weather conditions with the result that it was later in ripening and harvest was delayed by wet and stormy weather in September. Winter conditions set in early in November leaving some 18 per cent of the crop still in the fields waiting to be threshed.


Department of the Interior, Canada
Dominion Water Power and Reclamation Service
MAP SHOWING
MAJOR IRRIGATION PROJECTS
IN
SOUTHERN ALBERTA
Scale of Miles
10 5 0 10 20
LEGEND
Boundaries of Irrigation Projects
Irrigation Canals
C P R
WESTERN
SECTION
C P R.
EASTERN SECTION
NEW WEST IRRIGATION DIST
LITTLE BOW IRRIGATION DIST
CANADA LAND & IRRIGATION
COMPANY
LETHBRIDGE NORTHERN
IRRIGATION DIST
TABER IRRIGATION
DISTRICT
LETHBRIDGE SECTION
C P R
BLOOD I.R.
UNITED IRRIGATION
DISTRICT
RAYMOND IRRIGATION
DISTRICT
MAGRATH IRRIGATION
DISTRICT
MOUNTAIN VIEW
IRRIGATION DIST.
Calgary
Medicine Hat
Lethbridge
Macleod
High River
Claresholm
Cardston
Drumheller
Brooks
Taber
Buffalo
Champion
Travers
Barons
Keho Lake Reservoir
Lake McGregor
Lake Newell
Red Deer River
South Saskatchewan River
Belly River
FIFTH MERIDIAN
International Boundary
ALBERTA
BRITISH COLUMBIA
Coutts
Warner
Milk River
R 29 R 28 R 27 R 26 R 25 R 24 R 23 R 22 R 21 R 20 R 19 R 18 R 17 R 16 R 15 R 14 R 13 R 12 R 11 R 10 R 9 R 8 R 7 R 6

During the past season 10,012 acres were irrigated, a decrease of 46,383 acres, from 1926 figures. The total cropped area was 78,420 acres, which produced crop values amounting to $2,700.185 according to the district's unit values, representing a per acre return of $34.40.

Water was turned into the system on April 24 and the headgates closed on October 31, a total of 63,633 acre-feet being diverted into the main canal from the Oldman river. The highest daily discharge recorded was 410 cubic-feet per second on July 16 and the average daily flow for the month of maximum demand was 259 cubic-feet per second during July. At a check gauging station situated 2½ miles north of the Oldman River flume the total diversion recorded was 46,910 acre-feet and the maximum daily discharge 334 cubic-feet per second on July 16. The average daily flow for the month of maximum demand was 195 cubic feet per second during July. The difference in these quantities is due to canal losses through 6·9 miles of gravel section of the main canal. This water, however returns to the Oldman river within a mile or two of the leaky section.

The total precipitation recorded for the year was 23·85 inches, which amount has only been exceeded twice during the past 26 years, i.e. in 1902 and 1916. The seasonal precipitation as recorded at the Government Experimental Station at Lethbridge was as follows: April 1·48, May 7·32, June 1·60, July 1·93, August 1·74, September 3·29, or equal to 17·36 inches. The period free from damaging frost extended from May 9 to September 26, equal to 140 days.

United Irrigation District

This district diverts its water from the Belly river in sec. 13, tp. 3, rge. 28, w. 4th mer. At the close of the year there were 34,248 acres classified as irrigable as compared with 36,158 in 1926, the reduction being due to railway right of way and minor changes. Very little water was used in this district for irrigation owing to generous and well distributed rainfall throughout the growing season. However, water was kept running through the system during the entire season but was used chiefly for domestic and stock watering purposes, only 41 acres being irrigated as compared with 10,826 in 1926.

Crops in this district were below average, the late seeding followed by cold wet weather delayed ripening and kept many very promising crops still green when the frost arrived. Hail was also responsible for considerable damage.

Water was turned into the system on May 16 and the headgates closed on October 21, a total of 11,400 acre-feet of water being diverted from the Belly river. The highest daily discharge recorded was 66 cubic-feet per second on October 20 and the average daily flow for the month of maximum demand was 49·2 cubic-feet per second during August.

The precipitation as recorded at Glenwood during the growing season was 25·77 inches, made up as follows: May, 10·54; June, 2·50; July, 4·09; August, 2·67; September, 5·97.

During the past year the Canadian Pacific Railway Company has extended its Cardston branch 26·9 miles, giving the district splendid transportation facilities. Two stations with elevator facilities have been built within the district, one at Hillspring and one at Glenwood, the present terminus.

The rate levied per irrigable acre for the operation of the system was $1.35. The amount expended on repairs and maintenance was $1,234. The total bonded indebtedness at the close of the year was $536,978. Soil drifting and the silting of canals and small ditches is causing the district officials considerable concern. Consideration is being given to the purchase of a ditch cleaning machine which will operate with the water running in the system. Other irrigation districts have already found it necessary to operate these mechanical excavators in order to keep their lateral system up to capacity.

Magrath Irrigation District

This district obtains its water from the St. Mary river, the supply being carried through the works of the Alberta Railway and Irrigation Company to the districts's headgates.

The construction of the system was completed during the summer and the official opening ceremony took place at Magrath on June 24, when water was turned into the main canal for priming purposes.

The acreage now being administered by the district includes 5,047 acres for which the new works have been constructed and in addition 1,928 acres of water right lands formerly operated by the Alberta Railway and Irrigation Company, making a total area of 6,975 acres of irrigable land. During the season 1,235 acres were irrigated or 17·7 per cent of the area.

There are two diversion headworks to serve the lands now included in this district, one located on the SW. $\frac{1}{4}$ sec. 9, tp. 5, rge. 22, W. 4th mer. and referred to as the Magrath Lateral Headgates and the other in SW $\frac{1}{4}$, sec. 28, tp. 4, rge. 23, W. 4th mer. and known as the Spring Coulee Headgates. Water was turned into the Spring Coulee canal on June 17 and the headgates closed on October 5, a total of 1,020 acre-feet being diverted. The maximum daily discharge recorded was 10·3 cubic-feet per second on July 7. The headgates of the Magrath lateral were opened on June 26 and closed on October 8. A total of 890 acre-feet was diverted and the maximum daily discharge recorded was 14·4 cubic-feet per second on July 14.

The bonded indebtedness at the close of the year was $200,000 and the total amount expended on construction to date was $80,000.

Raymond Irrigation District

This district receives its water supply from the St. Mary river through the works of the Alberta Railway and Irrigation Company. The district has an agreement with the company whereby the company delivers 40·0 cubic-feet of water per second during the irrigation season to the district's headgates in the NE. $\frac{1}{4}$, sec. 5, tp. 6, rge. 21, W. 4th mer.

The district's newly constructed works serve 6,441·2 irrigable acres and in addition the district operates and supplies service to 8,688·5 irrigable acres, under an agreement with the Alberta Railway and Irrigation Company. The total irrigable area in the district is, therefore, 15,129·7 irrigable acres. The operation and maintenance of the system is in charge of a watermaster appointed by the district.

A map showing the location of the various major irrigation projects and their main canal systems is appended.

Project Crop Returns

In order to arrive at a fair comparison of the per acre returns from the various projects it has been considered desirable to establish uniform unit values for this purpose. Tables based on such unit values have therefore been prepared summarizing the crop returns submitted by each of the irrigation districts. It should be noted, however, that the data thus supplied include crops grown within the district on the total area cultivated, whether actually irrigated during the season or farmed as " dry " land. These tables, which appear hereunder, afford a very interesting study of the per acre returns from the various projects. It is of particular interest to note that the district in which most advice and assistance has been rendered during the past three or four years in connection with the irrigation extension work is the one showing the highest per acre return.

Crop	Unit value	C.P.R. Western Section			C.P.R. Eastern Section		
		Acres	Yield per acre	Value per acre	Acres	Yield per acre	Value per acre
	$ cts.			$ cts.			
Forage—							
Alfalfa	13 00	1,792	2·00	26 00	14,722	1·6	20·80
Sweet clover	13·00	1,101	0·5	6 50	...	...	...
Green oats	12 00	6,231	1·2	14 40	1,750	1·15	13·80
Other hay	10 00	3,514	1·1	11 00	2,575	1·11	11 10
Greenfeed	...	...	...	...	...	...	...
Timothy	13 00	317	0·9	11 70	...	...	...
Pasture—							
Sweet clover	...	...	...	...	...	...	...
Mixed grass	...	2,898	...	*25 00	1,922	...	25 00
Alfalfa	...	...	...	...	...	...	...
Grains—							
Wheat	1 15	172,268	21·9	25 18	33,657	28·4	32·66
Oats	0·52	23,599	43·6	22 67	9,269	44·2	22·98
Barley	0 68	5,174	27·8	18 90	4,195	39·8	27·00
Rye	1 00	215	17·4	17 40	...	...	...
Flax	1 60	130	6·7	10 72	475	11·6	18·56
Roots—							
Sugar beets	7 00	...	...	...	...	...	...
Potatoes	15 00	217	4·1	61 50	87	4·29	64·35
Cultivated—							
Corn	...	...	...	...	51	15·1	45·30
Garden	...	...	...	...	227	...	70·70
Miscellaneous	...	1,108	...	20·00	2,272	...	*20·00
Total crop area	...	218,564	...	24·11	71,202	...	26·84
New alfalfa	...	475	...	...	2,461	...	...
New clover	...	...	...	...	201 (new 10 Timothy)	...	...
Total crop seeded	...	219,039	...	...	73,874	...	...
Summer fallow	...	106,489	...	...	9,590	...	...
Breaking	...	5,997	...	...	...	...	...
Unbroken land	...	90,011	...	...	96,369	...	...
Idle land and building plots	...	3,968	...	...	...	...	...
Total arable land	...	425,504	...	...	179,833	...	...
†Less	...	...	...	...	† 2,672	Duplications for nurse crop	
					177,161		

* Estimated,

Crop	Unit value	Canada land and irrigation			New west		
		Acres	Yield per acre	Value per acre	Acres	Yield per acre	Value per acre
	$ cts.			$ cts.			$ cts.
Forage—							
Alfalfa	13 00	1,455	2·18	28 34	104	2·0	26 00
Sweet clover	13 00	...	...	...	...	...	...
Green oats	12 00	...	...	...	94	2·0	24 00
Other hay	10 00	65	1·80	18 00	4·5	3·0	30 00
Green feed	...	...	...	...	...	...	...
Timothy	13 00	...	...	...	...	...	...
Pasture—							
Sweet clover	...	...	...	...	...	...	...
Mixed grass	...	448·7	...	25 00	...	...	...
Alfalfa	...	...	...	...	...	...	...
Grains—							
Wheat	1·15	11,358·1	27·0	31 05	2,639	30·1	34 61
Oats	0 52	1,691·0	38·0	19 76	223	59 48	30 93
Barley	0 68	415·0	41·2	28 02	100	42·50	28 90
Rye	1 00	...	...	...	...	...	...
Flax	1 60	1,092·5	11·7	18·72	12	12·50	20 00
Roots—							
Sugar beets	7 00	...	...	...	...	...	...
Potatoes	15 00	63·8	9·8	147 00	3	2·0	30 00
Cultivated—							
Corn	...	9·0	...	21 67	...	...	...
Garden	...	48·6	...	70 70	...	...	...
Miscellaneous	...	...	...	...	† 10	...	20 00
Total crop area	...	16,646·7	...	29 12	3,189·5	...	33 47
New alfalfa	...	889·0	...	...	20·0	...	...
New clover	...	...	...	...	...	...	...
Total crop seeded	...	17,535·7	...	...	3,209·5	...	...
Summer fallow	...	...	...	...	...	...	...
Breaking	...	2,073·8	...	...	...	...	...
Unbroken land	...	...	...	...	450	...	...
Idle land and building plots	...	{ 640·1 229·1	...	...	...	...	...
Total arable land	...	20,478·7	...	...	3,659·5	...	...
	...	878·5	Less—Duplications for alfalfa with nurse crop				
		19,600·2					

Estimated.
Alfalfa seed.

Crop	Unit value	Lethbridge Northern			A. R. & I. Co. (C.P.R. Lethbridge)		
		Acres	Yield per acre	Value per acre	Acres	Yield per acre	Value per acre
Forage—	$ cts.			$ cts.			$ cts.
Alfalfa	13 00	2,535	2·2	28 60	9,485	2·00	26 00
Sweet clover							
Green oats							
Green feed	12 00	3,894	1·2	14 40	1,311	2·15	25 80
Timothy	13 00	471	1·0	13 00	6,349	1·46	18 98
Grass hay	10 00	835	0·9	9 00			
Pasture—							
Sweet clover					6,417		25 00
Mixed grass							
Alfalfa							
Grains—							
Wheat	1 15	60,161	33·7	38 75	30,635	32·32	37 17
Oats	0 52	5,702	43·8	22 78	4,283	47·42	24 66
Barley	0·68	2,267	32·0	21 76	2,612	35·75	24 31
Rye	1·00	223	23·0	23 00			
Flax	1 60	632	14·0	22 40	648	19·10	30 56
Roots—							
Sugar beets	7 00				887	7·82	54 74
Potatoes	15 00	241	4·0	60 00	1,300	5·50	82 50
Cultivated—							
Corn		95	1·52	11·86	103	7·35	22 05
Garden	70 70	287		70 70	274		70 70
Miscellaneous					71		104 40
Total crop area		77,343		35 01	64,375		29 97
New alfalfa		1,077			71		
New sweet clover					† 163		
Total crops seeded		78,420			64,609		
Summer fallow					15,137		
Unbroken land					12,709		
Idle land and building plots					5,824		
Total arable land					98,279		

Crop	Unit value	Magrath			United		
		Acres	Yield par acre	Value par acre	Acres	Yield per acre	Value per acre
Forage—	$ cts.			$ cts.			$ cts.
Alfalfa	13 00	731	1·81	23 53	1,073	2·01	26 13
Sweet clover							
Green oats							
Green feed	12 00	356	1·84	22 08	1,627	0·99	11 88
Timothy	13 00				625	1·41	18 33
Grass hay	10 00	603	1·63	16 30	587	1·10	11 00
Pasture—							
Sweet clover					9,271		*25 00
Mixed grass							
Alfalfa							
Grains—							
Wheat	1 15	7,704	28·23	32 46	23,043·16	[illegible]	12 67
Oats	0 52	1,134	45 98	23 91	1,745	1 7[illegible]	9 22
Barley	0 68	420	38·52	26 13	333	10·64	7 23
Rye	1 00	10	30·00	30 00			
Flax	1 60						
Roots—							
Sugar beets	7 00	586	7·29	51 03	624	3·70	25 90
Potatoes	15 00	120	7·48	112 20	30	6·00	90 00
Cultivated—							
Corn		50	3·00	9 00	10		
Garden	70 70	51		70 70	35		70 70
Miscellaneous					7		28 00
Total crop area		11,765		31 52	39,010·16		16 13
New alfalfa					**277		
New sweet clover							
Total crops seeded		11,765			39,287·16		
Summer fallow		6,146			14,579·00		
Unbroken land							
Idle land and building plots					912·90		
Total arable land					54,779·06		

† (Destroyed crop). * Estimated. ** Note.—9,215 acres of seeded crop was not harvested.

IRRIGATION PROJECTS NOT YET IN OPERATION

Little Bow Irrigation District

This project diverts its water from the Highwood river on the NW. $\frac{1}{4}$ sec. 6, tp. 19, rge. 28, W. 4th mer., near the town of High River. During the irrigation season, May 1 to September 30, some 1,504 acre-feet of water were diverted from the Highwood river into the Little Bow river. During the winter season October 1, 1926, to April 30, 1927, a small stream was diverted to keep the channel and the pools replenished and fit for domestic and stock watering purposes. During this period the total diversion amounted to 4,784 acre-feet.

The bonded indebtedness of the district as at the close of the year was $26,000, the cost of management $288 and expenditure on repairs $102. There are 3,092·7 irrigable acres in this project but as none of the pumping plants necessary to raise the water from the channel of the Little Bow river have been constructed, no irrigation has been possible. The number using this diverted water for domestic and stock watering purposes along the course of the Little Bow river is reported as 100.

Mountain View Irrigation District

Authorization for the construction of the necessary works in connection with this district was issued on June 23, 1925. Plans for the major structures have been prepared and submitted to the district in accordance with their request for engineering assistance. These plans have not yet been filed by the district and no construction work has been undertaken during the past season.

Alkali Test Plots at Maple Creek, Saskatchewan

These experimental plots have now been carried on for 6 years to obtain some reliable data regarding the effect of irrigation on heavy soils with high alkali content. Observations to date indicate that alfalfa and cultivated grasses continue to produce heavy crops, while the wheat yield was only fair due to extraneous causes. The general movement of the soil moisture from year to year is apparently downwards and beyond the 6-foot level. It is not however possible to state definitely that any large amount of alkali is accompanying the movement in this direction. It can be definitely stated that the alkali is not moving upward. It is proposed to continue the experiments over a further period of 4 years.

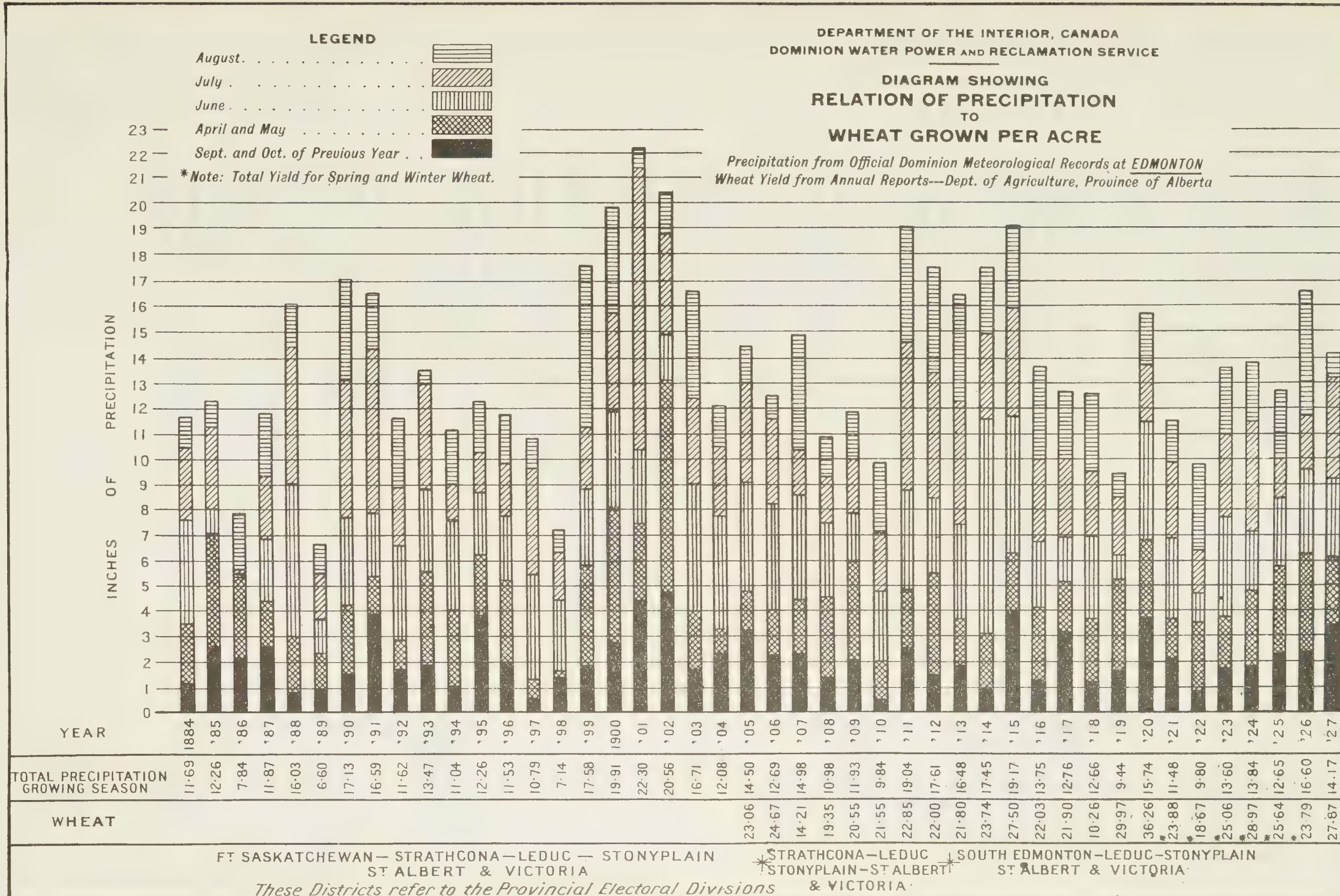
Meteorological Data

The two following plates Nos. 8 and 9 illustrate the average conditions in the central and semi-arid regions of Alberta respectively. Plate No. 8 shows that the natural precipitation is normally adequate to ensure average yields. Plate No. 9 however again indicates that in a normal year the natural precipitation is insufficient to furnish the moisture required to produce an average crop. Both graphs cover a period of 40 years of record.

Farm Demonstration and Extension Work

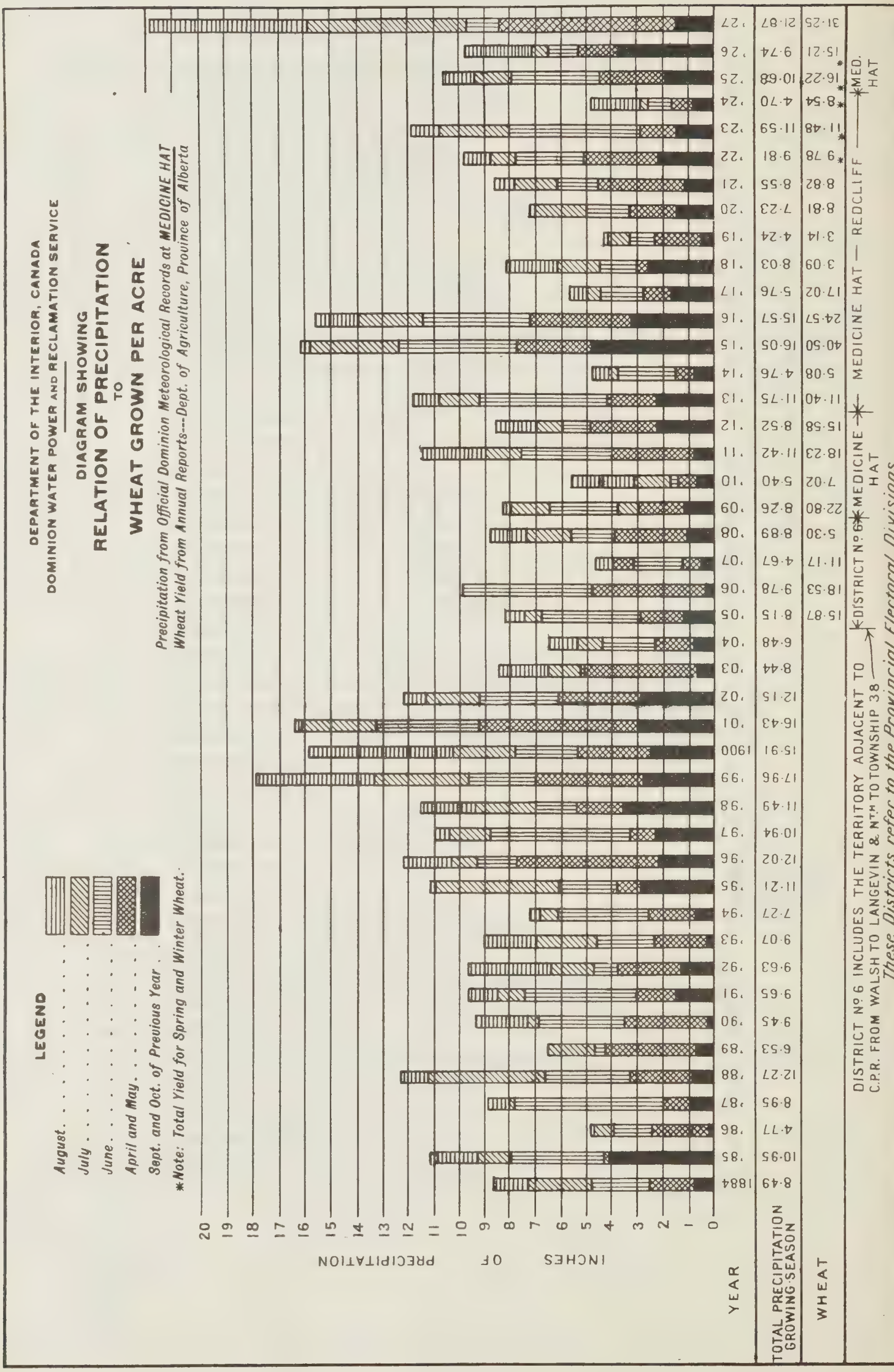
During the season aid was again given to new settlers on irrigated lands in the layout of their farm laterals, along the same lines as in other years. The demand for surveys was much lighter than usual due to the heavy rainfall in May. Many farmers requested ditch surveys in anticipation of a dry period later in the growing season but, as the rainfall proved ample for crop needs except for a period at the end of July, many of the projected ditches were not constructed.

Very little rain was received between July 15 and August 12 and during the latter part of July wheat crops suffered to some extent from lack of moisture and would have been benefited by an irrigation in the earlier part of this dry



YEAR	TOTAL PRECIPITATION GROWING SEASON	WHEAT
1884	11·69	
'85	12·26	
'86	7·84	
'87	11·87	
'88	16·03	
'89	6·60	
'90	17·13	
'91	16·59	
'92	11·62	
'93	13·47	
'94	11·04	
'95	12·26	
'96	11·53	
'97	10·79	
'98	7·14	
'99	17·58	
1900	19·91	
'01	22·30	
'02	20·56	
'03	16·71	
'04	12·08	
'05	14·50	23·06
'06	12·69	24·67
'07	14·98	14·21
'08	10·98	19·35
'09	11·93	20·55
'10	9·84	21·55
'11	19·04	22·85
'12	17·61	22·00
'13	16·48	21·80
'14	17·45	23·74
'15	19·17	27·50
'16	13·75	22·03
'17	12·76	21·90
'18	12·66	10·26
'19	9·44	29·97
'20	15·74	36·26
'21	11·48	*23·88
'22	9·80	*18·67
'23	13·60	*25·06
'24	13·84	*28·97
'25	12·65	*25·64
'26	16·60	*23·79
'27	14·17	27·87

PLATE 9


DEPARTMENT OF THE INTERIOR, CANADA
DOMINION WATER POWER AND RECLAMATION SERVICE
DIAGRAM SHOWING
RELATION OF PRECIPITATION
TO
WHEAT GROWN PER ACRE
Precipitation from Official Dominion Meteorological Records at MEDICINE HAT
Wheat Yield from Annual Reports---Dept. of Agriculture, Province of Alberta
LEGEND
August
July
June
April and May
Sept. and Oct. of Previous Year
*Note: Total Yield for Spring and Winter Wheat.
INCHES OF PRECIPITATION
YEAR
TOTAL PRECIPITATION GROWING SEASON
WHEAT
DISTRICT No 6 INCLUDES THE TERRITORY ADJACENT TO C.P.R. FROM WALSH TO LANGEVIN & Nth TO TOWNSHIP 38
DISTRICT No 6
MEDICINE HAT
MEDICINE HAT — REDCLIFF
MED. HAT
These Districts refer to the Provincial Electoral Divisions

period. Farmers in general postponed the application of water, anticipating a recurrence of the rainy weather. From August 12 until harvest the rainfall was ample for crop requirements.

Irrigation investigations to determine the seasonal use of water by sugar beets were carried on in connection with a program of educational extension work among the beet growers tributary to the Raymond sugar factory. The result of this study is described in detail under the heading of "Seasonal Use of Water by Sugar Beets." A study was also made in the same district relative to the development of the sugar beet root system.

Season's Results

The results of the past season's work are given in the following table and on the "plot series record sheets" which are included in this report.

The water requirement of wheat was determined when grown under 5 different conditions of soil environment, that of oats and barley under 2, that of sugar beets under 8, that of alfalfa under 2, and that of peas, beans and corn under 1.

The average total depths of water used in producing the maximum crop yields during 1927 were:—

For alfalfa	29 ac. inches	Average yields	6·27 tons
For barley	14 "		81·0 bush.
For wheat	19 "		60·1 "
For oats	16 "		114·0 "
For peas	16 "		33·5 "
For beets	19 "		17·8 tons
For corn	13 "		6·75 "
Average	18 "		

—	Appl'd	Precip.	Received	Depth used	
	ft.	ft.	ft.	ft.	in.
Average for 7 different crops 1927	0·45	1·18	1·63	1·49	18
" 7 " 1926	1·63	0·46	2·09	1·84	22
" 9 " 1925	1·53	0·67	2·20	2·12	25
" 6 " 1924	1·65	0·58	2·23	2·04	24
" 9 " 1923	1·07	0·74	1·81	1·77	21
" 10 " 1922	1·40	0·60	2·02	2·02	24
" 9 " 1921	1·42	0·46	1·88	1·85	22
" 11 " 1920	1·45	0·41	1·86	1·83	22
" 7 " 1919	1·32	0·42	1·74	1·71	21
" 5 " 1918	1·83	0·25	2·08	1·72	21
Average					22

The average depth used in producing maximum crop yields in 1927, using 7 different crops, was 18 inches, as compared with an average of 22 inches for the past 10 years. Second crop after alfalfa or clover yielded more beets and sugar per acre than as the first crop after alfalfa or clover. Beets *following clover,* both first and second year after, yielded more beets and sugar per acre than when following first or second year *after alfalfa.*

BROOKS' DUTY OF WATER EXPERIMENT STATION

Climatology

Unusually high precipitation with correspondingly low evaporation losses was the outstanding feature of the weather at Brooks during the 1927 season. The total rainfall for the 6-month period, April to September, amounted to nearly 16 inches, exceeding the average for this period by 7·4 inches. Temperatures recorded give indications of the rainy weather which prevailed. There were no marked extremes. The mean temperature for April to September was

1·9 degrees below average while the records for October show 6·4 degrees above. The last spring frost occurred May 15 and the first fall frost September 18, a period of 125 days. The period free from killing frosts continued for 154 days, extending from May 3 to October 5. Stormy weather early in the season prevented work on the land until late in April and early May. Late seeding however was offset by favourable weather during the growing season and by the absence of early fall killing frosts. Tables Nos. 1A and 1B are a summary of the meteorological data observed at the station during 1927.

Table 1A.—*Summary Meteorological Data—April to October (inclusive), 1927, Brooks, Alta.*

Month	Temperature data °F.							Precipitation (ins.)			Evaporation (ins.)			Average Hourly wind velocity	Average per cent Rel. humidity 8.00 a.m. 6.00 p.m.
	Maximum recorded	Minimum recorded	Mean Maximum	Mean Minimum	Mean	Departure of mean from Average		Total	Departure from Average		Total	Departure from Average			
						+	−		+	−		+	−		
April	80·0	8·0	51·9	27·0	39·4	......	2·8	2·13	1·14	......	1·49	......	1·38	12·2	64·0
May	78·0	23·0	57·9	36·7	47·3	......	4·1	4·41	3·48	......	2·42	......	2·80	11·0	68·0
June	82·5	37·5	72·3	48·1	60·2	......	0·4	3·76	1·79	......	3·90	......	1·48	7·2	73·0
July	89·0	41·0	77·9	52·1	65·0	......	2·2	2·61	1·11	......	3·59	......	2·57	5·7	69·0
August	87·5	41·0	77·1	48·3	62·7	......	1·5	1·09	......	0·45	2·98	......	1·82	5·6	65·0
September	80·5	30·0	66·4	40·2	53·3	......	0·4	1·74	0·28	......	1·91	......	1·36	8·1	73·0
October	81·0	19·5	60·0	32·8	46·4	6·4	......	0·73	......	......	1·56	......	......	8·4	72·5
Seasonal Mean (Oct. not included)			67·2	42·1	54·6	......	1·9	......	......	......	......	......	......	8·3	68·6
Total (Oct. not included)						0·0	11·4	15·74	7·80	0·45	16·29	......	11·41	......	......
Total Net Deviation *(Oct. not included)						......	11·4	......	7·35	......	......	......	11·41	......	......

Table 1B.—*Mean Temperatures, Precipitation and Evaporation, with Departures, from Averages for the Period April-October (inclusive), 1927, at Representative Points Throughout the Irrigated Sections of Alberta.*

—	Month	Strathmore El. 3190		Brooks El. 2461		Vauxhall		Coaldale El. 2828		Macleod		Raymond	Glenwood	Summary	
		Means and Totals 1927	Departures 1915-24 averages	Means and Totals 1927	Departures 1915-24 averages	Means and Totals 1927	Departures 1915-24 averages	Means and Totals 1927	Departures 1915-24 averages	Means and Totals 1927	Departures	Means and Totals 1927	Means and Totals 1927	Average Means and totals	Average net deaprtures
Temperature	April	36·8	−0·2	39·4	−2·8	39·2	−4·8	39·1	−2·9	40·3	−1·7	....	37·5	38·9	−2·5
	May	44·6	−2·4	47·3	−4·1	41·1	−10·9	46·5	−3·5	46·2	−3·8	45·2	38·2	45·4	−4·9
	June	56·8	+2·8	60·2	−0·4	58·0	−2·0	60·0	+1·0	58·6	+0·6	58·9	55·3	58·3	+0·4
	July	59·7	+0·7	65·0	−2·2	63·2	−3·8	62·8	−2·0	62·4	−1·6	62·2	61·8	62·4	−1·8
	August	59·2	−3·2	62·7	−1·5	60·8	−3·2	62·0	+5·0	62·8	+0·8	60·5	60·7	61·2	+0·9
	Spetember	49·2	−0·8	53·3	−0·4	51·7	−3·3	52·8	−1·1	52·4	−0·6	51·0	50·6	51·6	−1·2
	October	42·5	+3·5	46·4	+6·4	46·1	+3·1	48·6	+2·6	48·1	+3·1	46·1	44·7	46·1	+3·7
	Averages	49·8	+1·0	53·5	−0·7	51·4	−3·6	53·1	−1·3	53·0	−0·5	54·0	49·8	52·0	−0·8
Precipitation	April	0·40	−1·79	2·13	+1·14	8·30	+7·35	2·05	+0·93	0·44	−0·12	2·40	0·41	2·30	+1·50
	May	3·18	+1·25	4·41	+3·48	6·38	+5·14	6·53	+4·78	6·79	+4·68	8·50	10·54	6·62	+3·87
	June	3·23	+0·76	3·76	+1·79	3·14	+1·02	2·40	+0·16	2·14	−0·49	2·10	2·50	2·75	+0·73
	July	2·92	+0·98	2·61	+1·11	3·09	+1·40	1·54	+0·51	1·84	+0·07	2·90	4·09	2·71	+0·79
	August	0·81	−1·59	1·09	−0·45	3·34	+2·24	1·62	+0·26	1·23	−0 25	1·56	2·67	1·76	+0·04
	September	3·29	+1·58	1·74	+0·28	3·41	+2·20	2·13	+0·31	3·64	+2·41	3·30	5·97	3·35	+1·36
	October	0·57	−1·10	0·73	......	0·63	−0·11	0·66	−0·05	0·88	+0·28	0·60	1·84	0·82	−0·25
	Totals	14·40	+0·09	16·47	+7·35	28·29	+19·24	16·93	+6·90	16·56	+6·44	21·56	28·02	20·31	+8·04
Evaporation	April	2·09	−0·79	1·49	−1·38	......	......	2·89	−0·34	......	......	......	......	2·16	−0·84
	May	3·81	−0·91	2·42	−2·80	......	......	3·37	−1·55	......	......	......	......	3·20	−1·75
	June	4·00	−0·68	3·90	−1·48	......	......	4·04	−1·21	......	......	......	......	3·98	−1·12
	July	4·10	−1·22	3·59	−2·57	......	......	4·52	−1·86	......	......	......	......	4·07	−1·88
	August	3·82	+0·01	2·98	−1·82	......	......	3·83	−1·52	......	......	......	......	3·54	−1·11
	September	2·68	+0·02	1·91	−1·36	......	......	2·83	−0·94	......	......	......	......	2·47	−0·76
	October	1·53	......	1·56	......	......	......	2·22	......	......	......	......	......	1·77	......
	Totals	22·03	−3·57	17·85	-11·41	......	......	23·70	−7·42	......	......	......	......	21·19	−7·46

Crops Investigated

The work at Brooks during 1927 on "duty of water" investigation completes the ten-year program started in 1918. The crops studied included wheat, oats, barley, corn, alfalfa, peas and sugar beets. The co-operative investigation on the effect of irrigation on the quality of wheat conducted from the University of Alberta was continued and some new work on alfalfa, sweet clover and cereal seeds was undertaken in co-operation with the Dominion Seed Branch. The results of the experiments conducted, not including the co-operative projects, are summarized in the following discussions. Tables showing details of irrigation, water used and yields are included.

Wheat Rotation.—The water requirements of wheat were observed under 5 varying soil conditions including 4 legume rotations and one non-legume rotation. Soil fertility as influenced by crop rotation was the main factor controlling yield. The results obtained in each series are summarized in Table I.

Table I

Series	Place in rotation	Intervening crops	Wheat yields 1927		Average water used, inches
			Max.	Ave.	
64–65	3rd year after alfalfa	Oats—Oats	69·0	60·0	20·2
66–67	3rd year after R. Clover	Beets—Corn	65·4	56·1	17·2
1– 5	1st year after Peas	Corn—Barley—Wheat	62·7	56·0	19·8
74–75	4th year after R. Clover	" " "	59·0	51·2	17·9
83	2nd year after Grass	Beets	44·3	41·5	19·2

The superiority of alfalfa as a soil improvement crop, considered over a term of years is well illustrated in the case of the 64-65 plots which show the highest maximum as well as highest average yields of the 5 series. The relatively high yields obtained the first year after peas in the 1-5 series, show that this legume is capable of adding sufficient fertility for at least one good crop. Most important of all, however, is the difference in yield between the legume and non-legume rotations, which serves to illustrate the importance and possibilities of legumes as a factor in the production of wheat under irrigation.

Irrigation.—The moisture requirements of the wheat crop were almost entirely supplied by the unusually heavy precipitation received. Comparing the results obtained from different irrigation treatments single irrigations of 6 inches each gave highest average yields, higher in fact than the average yields from one or two 4-inch applications. Results from different irrigations are averaged in table II.

Table II

Irrigations applied	Dry land	1–4″	2–4″	3–4″	4–4″	1–6″	2–6″	4–6″ in 1926 0–0″ in 1927
Average water used	12	16	20	22	28	18	22	14
Average yields—Bush. per acre	52·5	56	60·4	55·0	56·8	60·6	55·5	55·9
Bushels per in. water used	4·6	3·5	3·1	2·4	2·0	3·4	2·5	4·0

Dry land plots produced an average of 52·5 bushels as compared with 60·6 bushels obtained with one 6-inch irrigation, while plots heavily irrigated in 1926 and previous years but not in 1927 produced an average of 55.9 bushels per acre. Irrigation in 1927 was therefore of little direct benefit, particularly

when the detrimental effect of excess moisture on quality is taken into account. Yields varied far more according to fertility than to irrigations applied. It must be remembered, however, that the high state of fertility obtained in the legume rotations depended directly upon irrigation during the normal years of scanty rainfall preceding.

Experimental data in detail obtained from the 5 wheat series are given in tables III to VII, inclusive.

Table III.—Irrigation Experiment Station, Brooks, Alberta—Plot Series Record 1927—Wheat (Marquis)

ROTATION B

Plot No.	Irrigation Date and Depth applied in Acre-feet per Acre													Duty of Water	Rainfall April First to Harvest	Total Depth Received	Total Depth used in Growing Crop	Yield per acre	Remarks
	June					July						August							
				22		7		14		23	30								
64 A														0·00	1·17	1·17	0·97	59·3	Mature Aug. 25
65 A				0·33										0·33	1·17	1·50	1·69	54·1	" " 30
64 C				0·33										0·33	1·17	1·50	1·49	69·0	" " 31
64 D				0·33				0·34						0·67	1·17	1·84	1·71	65·4	" " 31
64 E				0·33				0·34			0·33			1·00	1·17	2·17	1·37	58·9	" " 31
64 B				0·33		0·33					0·34			1·00	1·17	2·17	2·06	51·9	" " 30
65 B				0·33		0·33		0·34			0·34			1·34	1·17	2·51	2·48	64·7	" " 30
65 B				0·50										0·50	1·17	1·67	1·59	62·4	" " 30
65 D				0·50						0·50				1·00	1·17	2·17	2·21	57·8	" " 31
65 E														0·00	1·17	1·17	1·35	56·8	" " 31

Table IV

ROTATION B

	June					July						August							
		15	19	23	28		11	11	19		30								
66 A														0·00	1·15	1·15	1·16	55·1	Mature Aug. 26
B			0·33											0·33	1·15	1·48	1·21	57·0	" " 26
C				0·33										0·33	1·17	1·50	1·33	57·6	" " 28
D				0·33			0·34							0·67	1·17	1·84	1·62	60·5	" " 28
E				0·33			0·34				0·33			1·00	1·17	2·17	1·93	45·7	" " 30
67 A		0·33			0·33				0·34		0·33			1·33	1·17	2·50	2·14	54·7	" " 31
B		0·33			0·35		0·34		0·33		0·34			1·67	1·17	2·84	2·43	53·1	" " 28
C			0·50						0·50					1·00	1·17	2·17	1·92	53·3	" " 28
D			0·50						0·50		0·50			1·50	1·17	2·67	2·23	51·0	" " 28
E														0·00	1·17	1·17	1·08	65·4	" " 30

Table V

ROTATION E

Plot No.	June					July						August							
			16	21	25		8	13	15	25		1							
5 A														0·00	1·17	1·17	0·98	51·8	Mature Aug. 25
4 A				·33										0·33	1·17	1·50	1·18	58·8	" " 26
5				·33										0·33	1·17	1·50	1·25	50·6	" " 25
4				·33				·34						0·67	1·17	1·84	1·77	62·3	" " 26
3				·33				·33				·34		1·00	1·17	2·17	2·19	62·7	" " 30
2			·33				·33					·34		1·00	1·17	2·17	2·10	58·5	" Sept. 2
1			·33				·33		·34			·33		1·33	1·17	2·50	2·58	51·2	" " 2
3 A					·50									0·50	1·17	1·67	1·50	60·3	" Aug. 30
2 A					·50					·50				1·00	1·17	2·17	1·57	55·4	" Sept. 3
1 A														0·00	1·17	1·17	1·42	48·5	" " 4

Table VI

ROTATION D

Plot No.	Irrigation Date and Depth Applied in Acre-feet per Acre													Duty of Water	Rainfall April First to Harvest	Total Depth Received	Total Depth used in Growing Crop	Yield per acre	Remarks
	June					July						August							
			21	23	28	7		12		23	30								
74 A														0·00	1·15	1·15	0·88	43·8	Mature Aug. 23
B				·33										0·33	1·17	1·50	1·35	47·5	" " 23
C				·33										0·33	1·17	1·50	1·32	53·1	" " 30
D				·33				·34						0·67	1·17	1·84	1·58	53·4	" " 30
E				·33				·34			·33			1·00	1·17	2·17	1·79	38·4	" " 25
75 A			·33		·33						·34			1·00	1·17	2·17	2·02	52·5	" " 28
B			·33			·33		·34			·33			1·33	1·17	2·50	2·16	56·7	" " 30
C				·50										0·50	1·17	1·67	1·32	59·0	" " 28
D				·50						·50				1·00	1·17	2·17	1·63	55·4	" " 30
E														0·00	1·17	1·17	0·86	53·1	" " 28

Table VII

ROTATION C

Plot No.	June					July						August							
			18	23	28			11				2							
83 A				·33										0·33	1·17	1·50	1·21	41·9	Mature Aug. 25
B				·33										0·33	1·17	1·50	1·28	39·8	" " 26
C				·33				·34						0·67	1·17	1·84	......	44·3	" " 25
D				·33				·34				·33		1·00	1·17	2·17	2·06	40·8	" " 26
E			·33		·33							·34		1·00	1·17	2·17	1·94	39·6	" " 26

Oats Rotation.—Investigations on the water requirements of oats were confined to two series during 1927. The crop history of each and average yields obtained are shown in table VIII. The average yield of 103·3 bushels per acre obtained the fourth year after alfalfa is in sharp contrast to the average of 88.4 bushels obtained the second year after peas. The beneficial effects of the pea crop on soil fertility in Rotation " E ", consisting of peas, wheat, oats and barley, are confined largely to the wheat crop and extend only to a limited degree to the last two crops.

Table VIII

Series	Crop history					Yields—1927 bush. per acre		Average depth water used (inches)
	1927	1926	1925	1924	1923	Maximum	Average	
62–53	Oats	Wheat	Beets	Beets	Alfalfa	125·7	103·3	17·6
16–20	Oats	Wheat	Peas	Barley	Oats	104·0	88·4	17·9

Irrigation.—Comparing yields from the strictly dry land plots, oats showed more need for irrigation during 1927 than wheat, though as in the case of wheat one 6-inch irrigation only was needed to produce highest average yields. Table IX gives the average yields from different irrigation treatments. Results in detail are shown in tables X and XI.

Table IX

Irrigations applied	Dry land plots	1–4″	2–4″	3–4″	4–4″	1–6″	2–6″	4–6″ in 1926 None in 1927
Average yields	50·3	91·8	105·6	104·8	92·7	110·7	104·8	111·2
Average use of water	11·6″	14″	18·8″	22·2″	26·4″	15·4″	22·2″	11·4″
Bush. per inch used	4·3	6·6	5·6	4·7	3·5	7·2	4·7	9·7

Referring to table IX it will be noted that the different irrigation treatments show wide differences in efficiency considered in terms of bushels per inch of water used. The very high average yields obtained from stored moisture is particularly outstanding. Plots irrigated heavily in 1926 and previous years showed no need for irrigation in 1927, while oats on strictly dry land plots were greatly benefited by one 6-inch irrigation.

Table X.—Irrigation Experiment Station, Brooks, Alberta—Plot Series Record 1927—Oats (Banner)

ROTATION E

Plot No.	Irrigation Date and Depth Applied in Acre-feet per Acre — June 16	June 21	June 27	July 8	July 12	July 26	August 2	Duty of Water	Rainfall April First to Harvest	Total Depth Received	Total Depth Used in Growing Crop	Yeild per Acre	Remarks
16 A	....	....	....	....	....	....	....	0·00	0·73	0·73	0·91	33·7	Mature Aug. 22
17 A	....	·33	....	....	....	....	....	0·33	1·17	1·50	1·04	103·9	" " 25
16	....	·33	....	....	....	....	....	0·33	1·17	1·50	1·12	85·3	" " 24
17	....	·33	....	....	·34	....	....	0·67	1·17	1·84	1·56	102·7	" " 25
18	....	·33	....	....	·34	....	·33	1·00	1·17	2·17	1·80	104·0	" " 25
19	·33	....	....	·34	....	....	·33	1·00	1·17	2·17	1·80	90·1	" " 25
20	·33	....	....	·34	·33	....	·33	1·33	1·17	2·50	2·23	88·1	" " 25
18 A	....	....	·50	....	....	....	....	0·50	1·17	1·67	1·32	98·2	" " 24
19 A	....	....	·50	....	....	·50	....	1·00	1·17	2·17	1·97	91·7	" " 25
20 A	....	....	....	....	....	....	....	0·00	1·17	1·17	1·00	96·7	" " 25

Table XI

ROTATION B

Plot No.	June 22	June 25	July 8	July 13	July 23	July 30	August						
62 A	....	....	....	....	....	....	....	0·00	1·14	1·14	0·86	66·9	Mature Aug. 21
62 B	·33	....	....	....	....	....	....	0·33	1·17	1·50	1·35	88·4	" " 25
63 A	·33	....	....	....	....	....	....	0·33	1·17	1·50	1·16	90·0	" " 23
62 D	·33	....	....	·34	....	....	....	0·67	1·17	1·84	1·58	108·6	" " 28
62 C	·33	....	·34	....	....	·33	....	1·00	1·17	2·17	1·88	104·0	" " 28
62 E	·33	....	·34	....	....	·33	....	1·00	1·17	2·17	1·92	110·9	" " 28
63 B	·33	....	·34	·33	....	·33	....	1·33	1·17	2·50	2·17	97·3	" " 28
63 C	....	·50	....	....	....	....	....	0·50	1·17	1·67	1·24	123·3	" " 28
63 D	....	·50	....	....	·50	....	....	1·00	1·17	2·17	1·83	117·9	" " 28
63 E	....	....	....	....	....	....	....	0·00	1·17	1·17	0·89	125·7	" " 28

Barley Rotation.—The water requirements of barley were observed in two separate series of 10 plots each. The crop history of each series and the averages of the results obtained in 1927 are given in table XII. The 78-79 plots following the second year after clover show a comparatively small increase over the 21-25 plots following the fourth year after peas.

Table XII

Series	Crop history 1927	1926	1925	1924	Yields 1927—bush. per acre Max.	Ave.	Average water used (inches)
78–29	Barley	Wheat	Clover	Clover	85·0	69·6	14·4″
21–25	Barley	Oats	Wheat	Peas	77·0	63·0	16·1″

Irrigation.—Barley made the least use of irrigation of any of the cereal crops under investigation. In fact in Rotation "E" the highest yield was obtained without any irrigation while in the 78-79 series Rotation "D" the maximum was obtained with one single irrigation of 4 inches. Results from different irrigations are averaged in table XIII.

Table XIII

Irrigations applied	Dry land plots	1–4″	2–4″	3–4″	4–4″	1–6″	2–6″	4–6″ in 1926 None in 1927
Average yields................	70·9	70·9	69·1	71·2	63·0	65·3	57·1	56·8
Average use of water..........	8·9	13·8	16·9	21·4	22·4	15·8	19·8	9·6
Bush. per inch used............	8·0	5·1	4·1	3·3	2·8	4·1	2·9	5·9

It may be noted that slightly higher average yields were obtained with three 4-inch irrigations. Considered in relation to the other yields, however, this result can hardly be accepted as significant. The results in detail obtained in connection with the barley experiments are given in tables XIV and XV.

The result from plot 21A in rotation " E " deserves special mention. During the period 1918 to 1926 this plot received four 6-inch irrigations annually, excepting two different seasons when one and two irrigations were omitted. In 1927 no irrigations were applied. The point to be noted is the plot's present low state of fertility indicated not only by the low yield in 1927 but also by an examination of the soil which it may be stated has acquired a pale grey tint generally associated with a low organic matter content. This marked reduction in fertility may be attributed to two factors. (1) The inadequacy of peas as a soil improvement crop in a 4-year rotation, and (2) The excess irrigation applied annually during the past years. The present condition of 21A is simply the result of over irrigation greatly intensified in the absence of an adequate soil improvement crop.

Table XIV.—Irrigation Experimental Station, Brooks, Alberta—Plot Series Record 1927—Barley (Barks)

ROTATION D

Plot No.	Irrigation Date and Depth Applied in Acre-feet per Acre: June					July						August		Duty of Water	Rainfall April First to Harvest	Total Depth Received	Total Depth Used in Growing Crop	Yield per Acre	Remarks
				23	28		8	12		25	29	4							
78 A.....	....	....	....	....	....	....	....	....	....	....	....	....	....	0·00	1·15	1·15	0·62	64·8	Mature Aug. 22
B.....	....	....	....	·33	....	....	....	....	....	....	....	....	....	0·33	1·15	1·48	1·20	85·0	" " 23
C.....	....	....	....	....	·33	....	....	....	....	....	....	....	....	0·33	1·15	1·48	1·07	74·8	" " 23
D.....	....	....	....	....	·33	....	....	....	....	·34	....	....	....	0·67	1·15	1·82	1·46	77·0	" " 23
E.....	....	....	....	....	·33	....	....	....	....	·34	....	·33	....	1·00	1·15	2·15	1·29	72·5	" " 23
79 A.....	....	....	....	·33	....	....	....	·34	....	·33	....	·33	....	1·33	1·15	2·48	0·63	60·5	" " 23
B.....	....	....	....	·33	....	....	·34	....	....	....	·33	·33	....	1·33	1·15	2·48	2·08	61·2	" " 23
C.....	....	....	....	....	....	....	·50	....	....	....	....	....	....	0·50	1·15	1·65	1·18	70·1	" " 23
D.....	....	....	....	....	....	....	·50	....	....	....	·50	....	....	1·00	1·15	2·15	1·69	57·1	" " 23
E.....	....	....	....	....	....	....	....	....	....	....	....	....	....	0·00	1·15	1·15	0·84	72·9	" " 23

Table XV

ROTATION E

Plot No.	June					July						August							
				21	27		8	12	20	25		4							
25 A.....	....	....	....	....	....	....	....	....	....	....	....	....	....	0·00	1·17	1·17	0·86	77·0	Mature Aug. 27
24 A.....	....	....	....	·33	....	....	....	....	....	....	....	....	....	0·33	1·17	1·50	1·24	66·5	" " 28
25........	....	....	....	....	....	....	·33	....	....	....	....	....	....	0·33	1·17	1·50	1·09	57·2	" " 28
24........	....	....	....	....	....	....	·33	....	....	·34	....	....	....	0·67	1·17	1·84	1·36	61·2	" " 28
23........	....	....	....	....	....	....	·33	....	....	·34	....	·33	....	1·00	1·17	2·17	1·78	70·0	" " 29
22........	....	....	....	....	·33	....	....	·34	....	·33	....	·33	....	1·33	1·17	2·50	1·37	63·9	" " 29
21........	....	....	....	....	·33	....	·34	....	·33	....	....	·34	....	1·33	1·17	2·50	2·16	66·5	" " 29
23 A.....	....	....	....	....	·50	....	....	....	....	....	....	....	....	0·50	1·17	1·67	1·48	57·3	" " 28
22 A.....	....	....	....	....	·50	....	....	....	....	....	....	....	....	0·50	1·17	1·67	1·32	68·6	" " 28
21 A.....	....	....	....	....	....	....	....	....	....	....	....	....	....	......	1·17	1·17	0·76	40·7	" " 28

Corn.—The yields of corn for 1927 are below average mainly as a result of rainy and relatively cool weather which prevailed particularly during the period of germination and early growth. The plots were seeded May 10. The weather at that time was clear and fine with relatively high temperatures. Conditions looked promising for quick germination and early vigorous growth. Rainy weather set in May 17, however, with the result that germination and early growth were retarded during the cool weather which followed. The crop never fully recovered from this setback. Later seeding would undoubtedly have given higher yields.

Considering yields in relation to moisture, the results show that the precipitation received was practically equal to the moisture requirements of the crop and that very little irrigation was needed to produce even maximum yields. The dry plots in fact gave the highest yields and highest quality of mature seed. Results obtained are given in table XVI.

Table XVI.—Irrigation Experiment Station, Brooks, Alberta—Plot Series Record 1927—Corn (Minnesota No. 13)

ROTATION D

Plot No.	Irrigation Date and depth applied in acre-feet per acre									Duty of water	Rainfall April First to Harvest	Total Depth Received	Total Depth used in Growing Crop	Yield per acre	Remarks
	June		July		August										
		25	12	30	4	10	15	19						tons	
76-77A	......	......	......	......	......	......	......	......	0·00	1·06	1·06	......	5·28	Yield shown includes grain and stover air dry weight.
76-77B	......	......	......	......	......	......	......	......	0·00	1·06	1·06	......	4·72	
76-77C	......	......	......	......	......	......	......	......	0·00	1·06	1·06	......	6·73	
76-77D	......	......	0·25	......	0·25	......	......	......	0·50	1·06	1·56	......	6·39	
76-77E	......	0·25	......	......	......	0·25	......	......	0·50	1·06	1·56	......	4·70	
76-77F	......	0·25	......	0·25	......	......	0·25	......	0·75	1·06	1·81	......	5·88	All plots harvested September 30.
76-77G	......	0·25	0·25	......	0·25	......	......	0·25	1·00	1·06	2·06	......	5·49	
76-77H	......	......	0·38	......	......	......	......	......	0·38	1·06	1·44	......	5·33	
76-77J	......	......	0·38	0·38	......	......	......	......	0·76	1·06	1·82	......	5·62	

Beans.—The project devoted to beans includes a study of (1) variety, (2) moisture requirements and (3) time of irrigation. The factor of variety may be considered equally as important as moisture in this investigation, since varieties naturally vary greatly in suitability and to a lesser extent in moisture requirements. Suitability is determined mainly by adaptation to soil and climate and by the quality of the mature crop. In this regard the bean investigations at Brooks are proving highly successful. Standard varieties, including canning beans of the highest quality, are being produced. These include such varieties as the Pink bean, Red Kidney, Robust Pea bean, Luther Burbank, Lady Washington, Australian or Alberta Brown, Pinto, Cranberry and others. Great Northern, a large, white, late variety is being grown but does not always reach full maturity. The Lima bean too is unsuitable on account of late maturity. The same is true of most of the soy beans; one variety, however, named Wisconsin Early, is proving adaptable and promises to become a useful crop for conditions at Brooks. The soy bean is valuable as a soil improvement crop and as feed for stock.

The moisture requirement of the bean crop in 1927 was almost entirely supplied by the rainfall received. There was little and in some cases no need for irrigation. Time of application exerted some influence, though the modifying effect of weather conditions is evident. Late varieties benefited more by irri-

gations applied early in July while earlier varieties were favoured more by later irrigations. The high relative humidity in 1927 favoured the production of high yields. The yield and irrigation data for 5 varieties used in 1927 are given in table XVII.

Table XVII.—Bean Variety Tests and Irrigation Experiments, Brooks, 1927

Plot No.	Irrigation Date and Depth Applied in Acre-feet per Acre				Duty of Water	Rainfall April First to Harvest	Total Depth Received	Yield in Bushels per Acre						Remarks
	July		August					Red Kidney	Great Northern	Australian Brown	Soy	Luther Burbank	Averages	
	13	29	4											
59 A					0·00	1·31	1·31	17·8	47·0	35·0	20·5	41·7	28·5	
59 B	0·33				0·33	1·31	1·64	19·9	42·3	28·7	13·7	38·2	25·1	Great Northern variety on Plots 59C, 59D, 59E did not mature.
59 C			0·33		0·33	1·31	1·64	21·3	......	36·0	15·3	42·5	28·8	
59 D	0·33		0·34		0·67	1·31	1·98	18·5	......	36·4	11·7	39·8	26·6	
59 E		0·33			0·33	1·31	1·64	13·7	......	38·7	12·2	45·8	27·6	
							Averages..	18·2	44·6	35·0	14·7	41·6	......	

Alfalfa Hay.—The yield data of the alfalfa hay experiments of 1927 show a number of marked deviations as will be noted in tables XVIII and XIX. In the 56-57 series plot 57B gave the maximum yield of 5·83 tons per acre. Considered in relation to the yields of the other plots of the series, however, it is evident that the deviation noted cannot be considered significant. Instead, the yield of 5·32 tons obtained from 56D is to be regarded as maximum for this series. In the 54-55 series, a 4-year stand, yields show little relationship to irrigation. In fact, the variations noted are probably to be attributed as much to variation in soil as to difference in irrigations. The yield of 6·45 tons per acre from the non-irrigated plot, 54A, is extremely high and largely the result of stored moisture. Considering the two series as a whole, however, it is evident that the older established plots of 54-55 required less irrigation and produced higher yields than the more newly established alfalfa plots of the 56-57 series.

Alfalfa hay showed relatively greater benefit from irrigation than other crops under investigation at Brooks during 1927. No less than two 6-inch irrigations in addition to nearly 14 inches of effective rainfall were used to produce average maximum yields.

Table XVIII.—Irrigation Experiment Station, Brooks, Alberta—Plot Series Record 1927—Alfalfa (Grimm)

ROTATION A

Plot No.	Irrigation Date and Depth Applied in Acre-feet per acre													Duty of Water	Rainfall April First to Harvest	Total Depth Received	Total Depth used in Growing Crop	Yield per acre	Remarks
	June					July						August							
			17	22	25				20	25	28		10					tons	
54 A														0·00	1·15	1·15	1·04	6·45	First cutting July 7.
54 B			0·50											0·50	1·15	1·65	1·54	5·51	
54 C			0·50						0·50					1·00	1·15	2·15	2·06	6·72	Second cutting August 24.
54 D				0·50					0·50					1·00	1·15	2·15	2·16	5·72	
54 E			0·50							0·50				1·00	1·15	2·15	2·17	6·70	
55 A			0·50		0·50						0·50			1·50	1·15	2·65	2·47	6·02	
55 B			0·50		0·50						0·35		0·50	1·85	1·15	3·00	2·91	6·30	
55 C			0·33							0·34				0·67	1·15	1·82	1·50	5·80	
55 D			0·33		0·34						0·33			1·00	1·15	2·15	2·10	5·66	
55 E														......	......	......	......	......	55E discarded. 25% winter killed.

Table XIX

ROTATION A

Plot No.	Irrigation Date and Depth Applied in Acre-feet per acre													Duty of Water	Rainfall April First to Harvest	Total Depth Received	Total Depth used in Growing Crop	Yield per acre	Remarks
	June					July						August							
		9		16	25				20	25	28		10						
																		tons	
56 A														0·00	1·15	1·15	1·12	3·75	First cutting
56 B				0·50										0·50	1·15	1·65	1·71	4·68	July 7.
56 C				0·50					0·50					1·00	1·15	2·15	1·83	4·95	Second cutting
56 D					0·50				0·50					1·00	1·15	2·15	1·79	5·32	August 24.
56 E				0·50						0·50				1·00	1·15	2·15	1·42	4·78	
57 A		0·50			0·50						0·50			1·50	1·15	1·65	2·52	4·66	
57 B		0·50			0·50						0·50		0·50	2·00	1·15	3·15	2·86	5·83	
57 C		0·33								0·34				0·67	1·15	1·82	1·76	5·36	
57 D		0·33			0·34						0·33			1·00	1·15	2·15	2·23	5·36	
57 E		0·33			0·34						0·33		0·34	1·34	1·15	2·49	2·46	5·09	

Peas.—The moisture requirements of peas were observed in one single series of 10 plots. Details of irrigations applied, yields obtained and other data are given in table XX. The results show that irrigation was of little consequence in the production of peas at Brooks in 1927. The highest yield was obtained from 40A, a plot which was irrigated heavily in 1926, but received no irrigation in 1927. It will further be noted that 36A, a strictly dry land plot, yielded 29·2 bushels per acre which is only 4·3 bushels less than the maximum of the series. It is possible that yields were depressed by some factor, such as weather conditions or some disease.

Table XX.—Irrigation Experiment Station, Brooks, Alberta—Plot Series Record 1927—Peas (Prussian Blue)

ROTATION "E"

Plot No.	Irrigation Date and Depth Applied in Acre-feet per acre													Duty of Water	Rainfall April First to Harvest	Total Depth Received	Total Depth used in Growing Crop	Yield per acre	Remarks
	June					July						August							
			17	22	27	8		13			26	3							
																		tons	
36 A														0·00	1·19	1·19	0·95	29·2	All plots
37 A				0·33										0·33	1·19	1·52	1·19	28·0	harvested
36				0·33										0·33	1·19	1·52	1·55	28·9	September 9.
37				0·33				0·34						0·67	1·19	1·86	1·88	29·2	
38				0·33				0·33				0·34		1·00	1·19	2·19	2·33	30·5	
39			0·33			0·34						0·33		1·00	1·19	2·19	2·22	32·1	
40			0·33			0·34		0·33				0·33		1·33	1·19	2·52	2·45	32·0	
38 A					0·50									0·50	1·19	1·69	1·57	31·1	
39 A					0·50						0·50			1·00	1·19	2·19	2·03	33·3	
40 A														0·00	1·19	1·19	1·37	33·5	

Sugar Beets.—The study of sugar beet production under irrigation comprised the major project of the duty of water investigation at Brooks during 1927. Moisture requirements of beets were studied particularly in relation to soil fertility, time of irrigation and seasonal use. Yield data obtained include sugar content and beet tonnage and are shown in detail in tables XXIII to XXVI.

Rotation.—The rotations used include alfalfa, clover and grasses or non-legumes. The residual effect of the legumes on yield and quality as well as water requirements was observed in detail. For this purpose beets were grown one, two, three, four and five years after alfalfa and one and two years after

clover. In the non-legume rotation beets followed the third year after grass. Table XXI gives the averages of results obtained from each series. The averages given include results from dry land plots and plots which received one 4- and two 4-inch irrigations.

Table XXI

Series	Place of beets in rotation	Yield of beets per acre		Yield of sugar lbs. per acre			Average depth water used
		Max.	Ave.	Ave.	Max.	Ave.	
				%			(inches)
52–53	1st year after alfalfa	15·6	13·8	17·7	5,300	4,900	21·1
48	2nd " "	17·0	15·7	18·2	6,120	5,700	22·2
46	3rd " "	18·8	17·1	17·3	6,300	5,890	23·3
44	4th " "	20·3	....	....	6,800	....	21·2
42	5th " "	19·1	17·4	17·5	6,680	6,080	17·0
70	1st " clover	18·2	16·9	17·7	6,670	5,970	18·2
68	2nd " "	19·9	18·0	17·4	6,900	6,280	22·1
89–90	3rd " grass	10·0	9·7	16·9	3,650	3,370	20·5

The maximum yields of 20·3 tons of beets per acre and 6,800 pounds of sugar in the alfalfa rotation were obtained in the 44 series following the fourth year after alfalfa. Unfortunately the results from the dry plot of this series had to be discarded on account of certain local soil conditions which obtained, and the averages for this series are not available. It may be safely concluded, however, that for conditions in 1927, the fertility was highest following the fourth year after alfalfa and that even in the fifth year there is no marked evidence of decline. The comparatively low yield following immediately after alfalfa indicates the advisability of using an intervening crop. Yields following the first and second year after clover are high and indicate the readily decomposable nature of clover residue. A comparison of yields from the legume and non-legume series clearly indicates the importance of legumes on beet production. The uniformly high sugar content throughout all the beet series is a notable feature. Sugar percentages show very little decrease even with maximum yields. Favourable maturing weather during September and October was an important factor contributing toward this result.

Moisture Requirements.—Results obtained show definitely that on the average one irrigation only, in addition to the precipitation received, was sufficient to give maximum yields, with an average use of 18·5 inches. The relatively high yields produced without irrigation are the results of unusually heavy rainfall favourably distributed. The influence of irrigation on sugar content is not marked. The highest average tonnage of beets was obtained with an average decrease of only one-tenth of one per cent sugar content. Average results from different irrigation treatments are summarized in table XXII.

Table XXII

Irrigations applied	Yield per acre: Beets		Yield per acre: Sugar		Ave. per cent sugar in beets	Ave. inches water used	Lbs. sugar per inch water used
	Max.	Ave.	Max.	Ave.			
Nil	18·2	15·2	6,670	5,350	17·7	13·3	401
1-4″	20·3	16·5	6,900	5,780	17·6	18·5	312
2-4″	18·5	15·6	6,435	5,420	17·2	20·6	263
3-4″	17·1	14·4	6,180	5,080	17·2	26·7	190

Table XXIII.—Irrigation Experiment Station, Brooks, Alberta—Plot Series Record 1927—Sugar Beets (Kleinwanzleben)

ROTATION A

Plot No.	Irrigation Date and Depth Applied in Acre-feet per Acre													Duty of Water	Rainfall April First to Harvest	Total Depth Received	Total Depth used in growing Crop	Yield per acre	Sugar per cent	Remarks
	June					July						August								
					29						27		19							
42 A														0·00	1·37	1·37	0·89	16·6	16·8	
B					0·33									0·33	1·37	1·70	1·18	19·1	17·5	
C					0·33						0·34			0·67	1·37	2·04	1·49	15·9	16·8	
D					0·33						0·34			0·67	1·37	2·04	1·41	17·0	19·4	
E					0·33						0·34		0·33	1·00	1·37	2·37	2·20	17·1	18·1	
44 A														0·00	1·37	1·37	1·00	10·0	17·8	
B					0·33									0·33	1·37	1·70	1·77	20·3	16·7	
C					0·33						0·34			0·67	1·37	2·04	1·74	17·3	14·7	
D					0·33						0·34			0·67	1·37	2·04	2·40	17·2	18·9	
E					0·33						0·34		0·33	1·00	1·37	2·37	1·89	15·2	19·9	

Table XXIV.—Irrigation Experiment Station, Brooks, Alberta—Plot Series Record 1927—Sugar Beets (Kleinwanzleben)

ROTATION "A"

Plot No.	Irrigation Date and Depth Applied in Acre Feet Per Acre													Duty of Water	Rainfall April First To Harvest	Total Depth Received	Total Depth used in growing Crop	Yield per acre	Sugar per cent	Remarks
	June					July						August								
					29					25	26		19							
46 A														0·00	1·37	1·37	1·41	15·5	17·6	
B					0·33									0·33	1·37	1·70	1·74	18·8	16·0	
C					0·33					0·34				0·67	1·37	2·04	1·89	17·5	18·0	
D					0·33					0·34				0·67	1·37	2·04	2·30	16·6	18·4	
E					0·33					0·34			0·33	1·00	1·37	2·37	2·37	11·6	16·8	
48 A														0·00	1·37	1·37	1·05	15·2	19·3	
B					0·33									0·33	1·37	1·70	1·80	15·6	17·4	
C					0·33						0·34			0·67	1·37	2·04	1·89	15·5	17·9	
D					0·33						0·34			0·67	1·37	2·04	2·02	17·0	18·0	
E					0·33						0·34		0·33	1·00	1·37	2·37	2·48	16·1	18·2	

Table XXV

ROTATION "A"

Plot No.	Irrigation Date and Depth Applied in Acre-Feet Per Acre													Duty of Water	Rainfall April First to Harvest	Total Depth Received	Total Depth used in growing Crop	Yield Per acre	Sugar per cent	Remarks
	June					July						August								
							8			25	26		19							
52 A														0·00	1·37	1·37	0·88	13·0	18·9	
53 C														0·00	1·37	1·37	1·02	14·4	18·4	
52 B							0·33							0·33	1·37	1·70	1·18	14·1	17·7	
52 C							0·33				0·34			0·67	1·37	2·04	1·68	11·6	16·6	
53 A							0·33				0·34			0·67	1·37	2·04	1·83	15·6	17·0	
53 B							0·33				0·34		0·33	1·00	1·37	2·37	2·23	14·4	17·8	
68 A														0·00	1·37	1·37	1·48	17·2	15·7	
68 B							0·33							0·33	1·37	1·70	1·44	18·2	19·0	
68 C							0·33				0·34			0·67	1·37	2·04	1·91	19·9	17·1	
68 D							0·33			0·34				0·67	1·37	2·04	2·08	17·0	17·9	
68 E							0·33			0·34			0·33	1·00	1·37	2·37	2·30	16·0	17·4	

Table XXVI

ROTATION "B"

Plot No.	Irrigation Date and Depth Applied in Acre-feet per Acre: June					July						August		Duty of Water	Rainfall April First to Harvest	Total Depth Received	Total Depth used in growing Crop	Yield per acre	Sugar per cent	Remarks
					29					25	28		19							
70 A	....	....	....	....	....	....	....	....	....	....	....	....	....	0·00	1·37	1·37	1·04	18·2	18·3	
B	....	....	....	....	0·33	....	....	....	....	....	....	....	....	0·33	1·37	1·70	1·12	16·4	18·5	
C	....	....	....	....	0·33	....	....	....	....	....	0·34	....	....	0·67	1·37	2·04	1·63	16·3	16·6	
D	....	....	....	....	0·33	....	....	....	....	0·34	....	....	....	0·67	1·37	2·04	1·69	15·6	15·8	
E	....	....	....	....	0·33	....	....	....	....	0·34	....	....	0·33	1·00	1·37	2·37	2·10	14·7	15·7	

ROTATION "C"

Plot No.	June				29	July				25	28	August	19	Duty of Water	Rainfall April First to Harvest	Total Depth Received	Total Depth used in growing Crop	Yield per acre	Sugar per cent	Remarks
89–90B	....	....	....	....	....	....	....	....	....	....	....	....	....	0·00	1·37	1·37	1·20	9·8	17·3	
B	....	....	....	....	0·33	....	....	....	....	....	....	....	....	0·33	1·37	1·70	1·50	9·4	17·7	
C	....	....	....	....	0·33	....	....	....	....	....	0·34	....	....	0·67	1·37	2·04	1·75	9·8	15·8	
D	....	....	....	....	0·33	....	....	....	....	....	0·34	....	....	0·67	1·37	2·04	1·84	9·6	19·0	
E	....	....	....	....	0·33	....	....	....	....	....	0·34	....	0·33	1·00	1·37	2·37	2·25	10·0	16·8	

Table XXVII.—Monthly Use of Water in Inches—Sugar Beets at Brooks, 1927, showing distribution of rainfall, irrigations applied and results obtained

Monthly distribution of rainfall in inches	Months: May		June		July		Aug.		Sept.		Oct.		Total		Yield per acre	
	4·4		3·8		2·6		1·1		1·7		0·7		14·3			
Irrigations applied shown in acre-inches per acre	Irrigation applied	Water used	Irrigation applied	Water used	Irrigation applied	Water used	Irrigation applied	Water used	Irrigation applied	Water used	Irrigation applied	Water used	Irrigation applied	Water used	Tons of beets	Pounds of sugar
Plot Nos.																
48 A	......	0·8	......	4·1	......	3·8	......	3·3	......	1·1	......	0·1	0·0	13·2	15·2	5,850
48 B	......	4·0	4·0	5·9	......	5·3	......	2·9	......	1·2	......	1·1	4·0	20·4	15·8	5,430
48 C	......	3·2	4·0	6·3	4·0	8·5	......	3·0	......	2·5	......	3·7	8·0	27·2	15·5	5,550
48 D	......	2·7	4·0	6·4	4·0	6·9	......	3·8	......	2·7	......	3·6	8·0	26·1	17·0	6,120
48 E	......	4·5	4·0	6·9	4·0	9·3	4·0	6·4	......	2·5	......	0·4	12·0	30·0	16·1	5,840
52 A	......	4·2	......	1·9	......	3·4	......	3·0	......	0·3	......	0·8	0·0	13·6	13·0	4,920
53 C	......	1·5	......	4·8	......	2·3	......	2·8	......	1·6	......	2·2	0·0	15·2	14·1	5,000
52 B	......	0·7	......	1·9	4·0	6·8	......	2·4	......	1·6	......	1·1	4·0	14·5	11·6	3,850
52 C	......	1·4	......	3·8	8·0	9·3	......	4·1	......	2·0	......	2·4	8·0	23·0	15·6	5,300
53 A	......	3·8	......	3·5	8·0	10·3	......	3·9	......	0·9	......	0·7	8·0	23·1	14·4	5,130
53 B	......	3·0	......	3·9	8·0	10·5	4·0	3·3	......	2·1	......	0·1	12·0	22·9	14·4	5,300
89-90 A	......	2·0	......	3·0	......	6·7	......	3·0	......	0·6	......	1·0	0·0	16·3	9·8	3,410
89-90 B	......	1·0	4·0	5·4	......	6·8	......	2·4	......	0·4	......	1·5	4·0	17·5	9·4	3,330
89-90 C	......	1·2	4·0	5·4	4·0	9·2	......	3·1	......	0·4	......	0·8	8·0	20·1	9·8	3,110
89-90 D	......	2·6	4·0	6·1	4·0	7·1	......	4·5	......	1·4	......	2·1	8·0	23·8	9·6	3,650
89-90 E	......	3·4	4·0	6·4	4·0	8·0	4·0	6·9	......	2·0	......	1·5	12·0	26·2	10·0	3,340
89-90 F	......	2·8	4·0	6·3	4·0	6·9	......	3·9	......	2·1	......	0·7	8·0	22·7	11·9	4,200
89-90 G	......	4·0	......	4·7	4·0	8·5	8·0	7·8	......	0·9	......	0·9	12·0	26·8	11·0	3,720

Time of Irrigation.—The weather conditions during 1927 afforded rather limited scope for the study of this phase of sugar beet production. Results do indicate, however, that time was a factor of importance in applying the single irrigation required to produce highest average yields.

Beets irrigated late in July produced relatively high tonnage but only average sugar content. Maximum results therefore were obtained with the single irrigation applied July 12. This is in contrast to the results in 1926 when highest yields were secured with 3 irrigations, applied May 25, June 15 and July 15. The difference is mainly the result of variation in the amount and distribution of precipitation in the two seasons.

Seasonal Use of Water.—Three series of 5 or more plots each were used for observing time or seasonal use of water by sugar beets during 1927. These included series 48, 52-53 and 89-90. Soil samples from each plot were collected at intervals of 10 and 15 days throughout the season.

The results of yields from the 3 series in this project are exceptional in that maximum yields in each were obtained with 2 irrigations instead of the average of one irrigation required to produce the highest average yields in all of the 8 beet series grown at the Station in 1927. Variation in soil condition is likely the cause of the deviation noted in the case of the 3 series selected for seasonal use of water studies.

The results given in detail in table XXVII are summarized in table XXVIII to show the monthly use for dry land plots and plots which received one and two irrigations. The use for these 3 different conditions is averaged to give the mean monthly use of all plots. Percentage distribution of rainfall, irrigations applied and water used complete the table.

Table XXVIII—Summary of Seasonal Use of Water—Sugar Beets, Brooks, 1927

Month	Average use in inches with			Mean monthly use in inches	Distribution of rainfall in inches	Percent distribution of		
	No Irr.	One Irr.	Two Irr.			Rainfall	Irrns. applied	Water used
May	2·1	1·9	2·5	2·2	4·4	31	....	12
June	3·5	4·4	5·4	4·4	3·8	26	38	24
July	4·1	6·3	8·3	6·2	2·6	18	62	33
August	3·0	2·6	3·8	3·3	1·1	8	....	18
September	0·9	1·1	1·6	1·2	1·7	12	....	6
October	1·0	1·2	2·0	1·4	0·7	5	....	7
Totals	14·6	17·5	23·6	18·7	14·3	100	100	100

The average monthly uses shown, which represent losses from percolation below the root zone, evaporation from the soil surface and the moisture actually used by the crop, increased rapidly from 2·2 inches in May to 6·2 inches in July. In August the average use dropped sharply to 3·3 inches and 1·2 inch in September. The slightly higher use of 1·4 inch in October was the result of a heavy precipitation October 10. Considering the distribution of irrigation it is to be noted that the plots included in the above averages received 38 per cent of the total irrigations applied during June and 62 per cent during July. The heavy use recorded in July is no doubt partly the result of the high proportion of irrigations applied during that month. The results do indicate definitely, however, the value of the irrigations applied in July and serve to corroborate the results of the sugar beet time of irrigation experiments in which highest yields were obtained from irrigations applied July 12.

All beet plots in 1927 were seeded the first part of May, thinning was completed early in June and harvesting October 14. Stands obtained were uniformly good throughout all series and the best crop suffered little loss from disease or insect attack. Flea Beetles threatened serious damage early in June but were effectively radicated by dust treatments of copper carbonate.

Seasonal Use of Water by Sugar Beets

Field Studies, Stirling-Magrath, Alberta, 1927.—During the summer of 1927 irrigation investigations to determine the seasonal use of water by sugar beets were carried on in the Stirling-Magrath district of Alberta in connection with a program of educational extension work among the beet growers tributary to the Raymond Sugar Factory.

Purpose of Investigation

The purpose of this investigation was to secure data on the seasonal use of water by beets under field conditions and to correlate the information thus obtained with the results of a similar study carried on at Brooks. It was deemed especially desirable to secure data from this particular district as the major portion of the land devoted to beet culture is underlaid at depths ranging from 4 to 6 feet with an impervious stratum of clay or gumbo and is therefore subject to waterlogging if over-irrigated. This information would be directly available to the beet growers as a guide for the frequency and depth of irrigation necessary to secure the best results.

Methods of Obtaining Data

This investigation was carried on by a representative of the Dominion Water Power and Reclamation Service in co-operation with officials of the Canadian Sugar Factories Limited. Nine fields were selected upon which moisture determinations to a depth of 4 feet would be made with sufficient frequency to determine when and in what quantity irrigation water could be beneficially applied. Whenever the moisture content of any one of these fields dropped to the point where irrigation was needed, the person farming that particular field was so advised and aided by the irrigation specialist in the layout of the necessary field laterals and the regulation of the irrigating head so as to secure the application of the correct depth. In addition to the above program, any farmer of the district who wished to know as to whether or not his beet fields needed irrigation, could call on the irrigation specialist, who would visit the field and after determining the moisture content therein, advise the farmer of the irrigation requirements of his beet field.

On 4 of the 9 fields moisture observations were made every 7 to 10 days throughout the growing season for the purpose of determining the amount of water used by the beet crop during the different stages of its growth. These fields have been designated and described in the following text as: (1) Peterson, (2) Foster, (3) Hogensen, and (4) West Magrath. The water used by them during the season is shown on Diagram Nos. 1 and 2. Observations were also made on 5 other fields; namely, (5) Allen, (6-7) Sugar Co. NW., (8) Sugar Co. SE., and (9) Byrner. The observations on these latter fields were made monthly up to August 9 and from then on with similar frequency to fields No. 1 to 4.

Water Requirements of Sugar Beets

1. *Transpiration.*—The amount of water that a sugar beet plant will transpire at any stage of growth will depend upon (*a*) the amount of *water* held in the soil zone occupied by the roots; (*b*) the amount of energy, as light and heat received from the sun; (*c*) the relative *humidity* of the atmosphere as influenced by wind, rain, surface evaporation and shade; (*d*) the area of its leaf, and moisture absorbing root surface; and (*e*) the fertility of the soil or concentration of available soil solution nutrients.

2. *Percolation.*—The amount of water that is lost to the beet plant by percolation below the soil zone occupied by its roots will depend upon: (*a*) the texture of the soil, whether coarse and of low water retaining capacity as of sand, or fine and of high water retaining capacity as of clay; (*b*) the amount of water held in the root zone at the beginning of the season; and (*c*) the depth applied and frequency of irrigations.

3. *Evaporation.*—The amount of water that is lost to the beet plant by evaporation from the soil's surface is influenced by cultivation and shade of plants, temperature, humidity, sun's energy and amount of water in the soil.

WATER USED TO GROW CROP

When water is introduced into any soil for the purpose of growing a crop, whether as rainfall or as irrigation, it is extracted or lost from the plant's root zone by the 3 agencies above described. This combined loss represents the losses that of necessity occur in field practice and indicate that amount of water required to produce or grow the crop. These losses are herein referred to as "*Water Used to Grow the Crop.*"

Some of the irrigated plots at Brooks "Duty of Water" Station.

Many of the forces that influence the amount of water used in growing a crop are not within our control, such as temperature, humidity, light, general soil texture and to a great extent, leaf surface. We are, however, able to control the losses caused by the variation of the moisture content of the soil by correct irrigation practice, the losses influenced by varying soil fertility by the use of the proper system of crop rotation, and the losses due to evaporation and extent of leaf surface by seasonable farming operations.

THE OPTIMUM SOIL MOISTURE CONTENT

Investigations and observations carried out on the soils of the 9 fields under study in the Magrath-Stirling district showed that, with the exception of field No. 3, the optimum soil moisture content for sugar beets was attained when the soil of the root zone contained from 3 to 4 acre-inches of water per foot in depth of soil. For field No. 3 this content was found to be from 2 to 3 acre-inches. When the soils under study contained either more or less than the optimum content, conditions were not favourable for normal growth. Where the soil contained more than the optimum amount it was too wet and the excessive

amount of water reduced the soil temperature and the amount of air available for the growing roots. Where the soil contained less than the optimum amount it was too dry. The film of moisture was so thin around the soil grains and held to them with such great force that the roots could not extract it in sufficient daily quantities to provide for the needs of the plant.

Plate No. 10

This shows the *available* water content of the soil to a depth of 4 feet in acre-inches for 4 fields during the growing season or from the time of planting in the spring until the time of digging in the fall. The amount of non-available water, or water still remaining in the soil when the plant begins to wilt, was found to be 4·8 acre-inches in a 4-foot depth of soil for field No. 3 and 6·0 acre-inches in a depth of 4 feet for the other 8 fields.

The zone or range of optimum moisture content is shown shaded for each field. The irregular line shows the amount of available water contained in each field at any time during the season. Where this line lies above the shaded portion, the field was too wet· where below the shaded portion, the field was too dry. A rise in the position of the line indicates an increase in the water content of the field due to rainfall or irrigation. A lowering of the line indicates the amount and rate of use of water to grow the crop. As previously explained, this use or loss was due, not only to that amount of water used through the plant as transpiration, but also due in part to percolation and evaporation losses. The precipitation during the season is shown plotted above the water content curves. It amounted to 20·76 inches from April 1 to October 15, and except for the period July 20 to August 5, was ample for the requirements of the crop. During this period, all fields show large decreases in total water content, varying from 4 inches in No. 3 to 8½ inches in No. 1. On August 11 the available water content of field No. 1 had decreased to 5·2 inches and the beets were beginning to show a change of colour with some wilting of the lower leaves. Upon the advice of the writer this field received a 3-inch irrigation on August 12. On August 30 the water content of this field had again become depleted to the point where a second irrigation was necessary, but rainfall on August 31 and from September 7 to 15 brought the water content well up in the optimum zone again.

Field No. 2 should have received a 3-inch irrigation on August 12 to 15 also, but it was not possible to secure its application. Therefore, this field was too dry for normal growth for most of the period from August 7 to September 17.

These 4 graphs were kept up-to-date during the season and as the fields represented were located as follows: one at the east (3), one at the west (4), and two at mid-distance (1) and (2), of a district some 25 miles long and were, therefore, representative of the general soil conditions, *it was possible at all times to advise almost any beet grower in the district regarding the water requirement of his beet acreage.*

Plate No. 11

This diagram shows: (*a*) in centre of diagram the total depth of water used to grow the crop and the amount used during the different months or stages of growth for fields 1, 2, 3 and 4; (*b*) in 4 small graphs the water content of each field for each foot in depth in relation to the optimum range; and (*c*) by the dotted line in the small graphs, the rate and depth of tap root penetration.

Field No. 1, used a total depth of 21·5 inches of water to grow the crop. It received one 3-inch irrigation August 13. The graph for this field, (upper left on diagram) shows that the first 3 feet in depth were too wet until about July

PLATE 10

AVAILABLE WATER CONTENT OF SOIL FOR FOUR FIELDS DURING GROWING SEASON

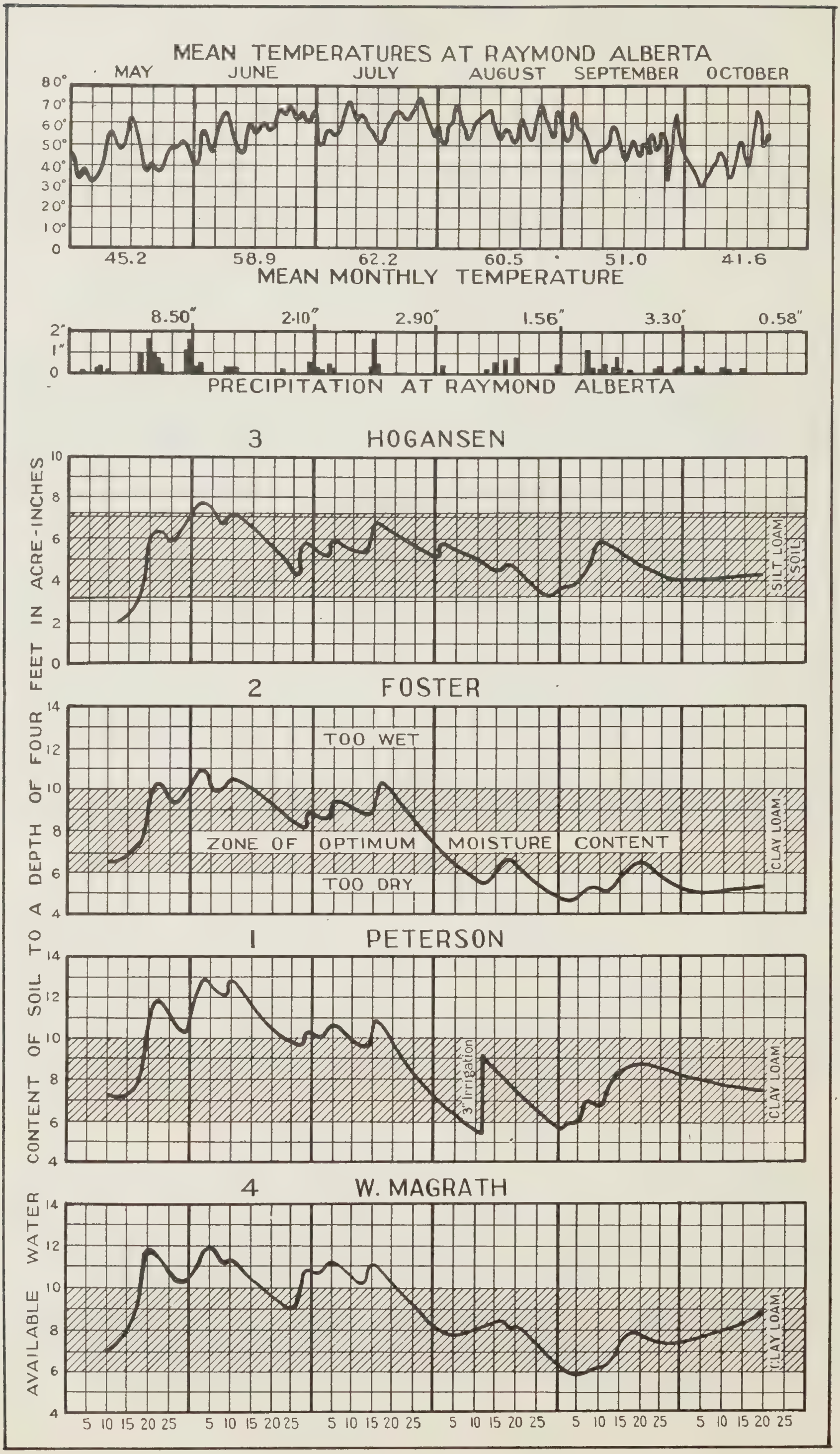


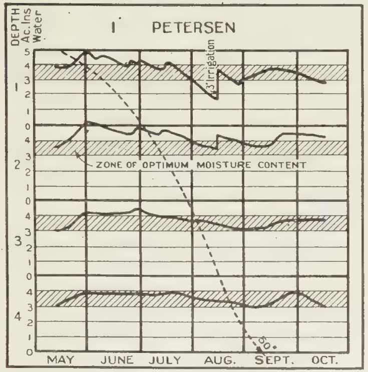
PLATE 11

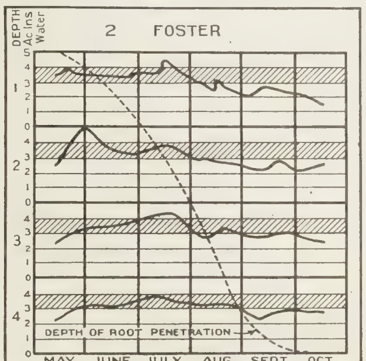
DEPARTMENT OF THE INTERIOR, CANADA
DOMINION WATER POWER AND RECLAMATION SERVICE

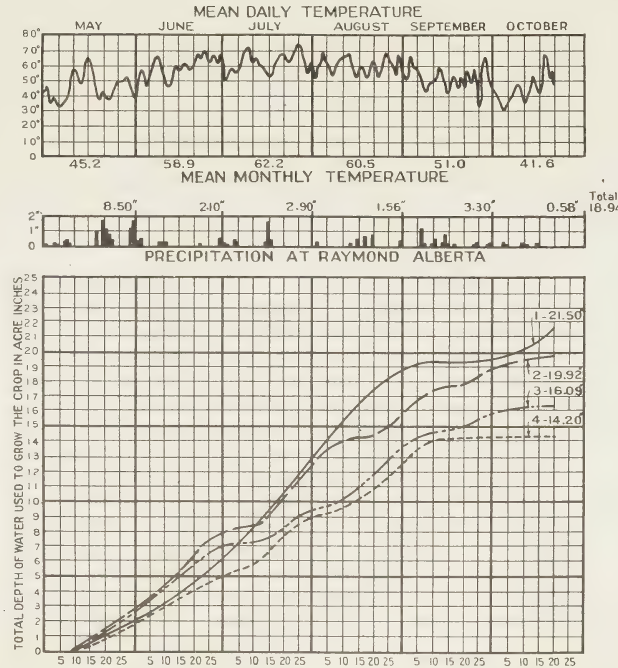
SEASONAL USE OF WATER BY SUGAR BEETS
MAGRATH-STERLING DISTRICT
1927

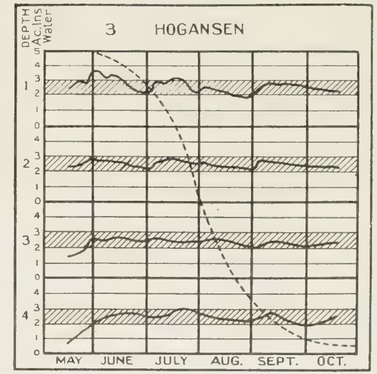
DEPTH OF WATER USED PER MONTH
IN ACRE INCHES

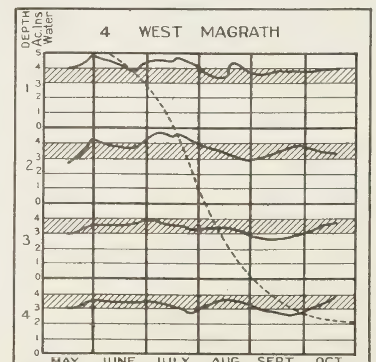
	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	TOTAL
1. PETERSEN	2.1	4.1	6.6	6.2	0.5	0.5	21.5
2. FOSTER	2.8	5.2	4.5	3.3	3.0	3.0	19.9
3. HOGANSEN	2.4	4.7	2.6	4.0	2.0	2.0	16.1
4. W.MAGRATH	1.2	3.3	4.0	3.2	2.0	2.0	14.2
MEAN	2.2	4.3	4.4	4.2	1.9	0.9	17.9











20. The rate of use from July 20 on was so high that on August 11 the moisture content of the first foot had been depleted to 1·2 inch of water or 1·8 inch below the lower limits of the optimum range. The second foot in depth had been depleted to a total water content of 3·2 inches or but 0·2 inch above the lower limits of the optimum range. A 3-inch irrigation raised the content of the first 2 feet in depth 2·9 inches. The third and fourth foot show no increase from this irrigation. This is an excellent illustration of the efficiency of a light irrigation, especially under conditions where the lower lying soil zones contained sufficient water. A 6-inch irrigation would have raised the moisture content of the third and fourth foot much higher than necessary for optimum growth. This field is comparatively well drained and shows no increase in the water content of the lower soil zones due to seepage or rise of ground water. The graph shows that, for the greater part of the growing season, the soil zone occupied by the beet roots on field No. 1 contained an optimum amount of water. During June and to July 20 the root zone was too wet and during the first 11 days in August too dry in the first 2 feet down. The dotted line running from the surface on May 15 to a depth of 50 inches on October 19 shows the depth of penetration of the tap roots at any period during the season and limits the soil zone occupied by the roots. This was determined by excavations made each month to the depth occupied by the roots. Of the total depth used—21·5 inches, 6·2 inches were used in May and June, 12·8 in July and August, and 2·5 inches in September and October.

Field No. 2, shows a total depth used to grow the crop of 19·92 inches. The soil was well drained and quite similar in texture to that of field No. 1. The second foot in depth was too wet during the last week in May and the first week in June. The first foot was too wet for about 5 days after July 14. The entire 4 feet in depth was too dry from about August 15 to the end of the season. This field shows a higher use during May and June than field No. 1, due to a greater portion of the rainfall received during that period being lost by percolation below the fourth foot in depth than was lost in field No. 1. The use during August is approximately 3 inches less than that of field No. 1, due to the low water content of field No. 2, during that period and the smaller amount of moisture available to the plant for transpiration. This field used during May and June 8·0 inches, during July and August, 7·8 inches, and during September and October, 4·1 inches.

Field No. 3, shows a total depth used to grow the crop of 16·09 inches. The soil of this field was a silt-loam much lighter and more pervious than that on any of the other fields and was underlaid at a depth of 4 to 4½ feet with a layer of gumbo. About July 15 water was noted at depths of 4 to 4·3 feet and apparently was moving along on top of the impervious layer as a result of percolation from higher lying, adjacent lands. The water content of this field increased faster than was consistent with the depth received as rainfall. The use curve for this field is not correct, as it does not show the exact amount used to grow the crop, as there is no way of determining the amount of water that moved into the lower soil zones as seepage or ground water from below. The data received are valuable in that they indicated the amount of water that would have to be supplied by irrigation or rainfall to fields subject, as this one is, to a supply of water from below, as seepage. Assuming that the crop grown on this field transpired the same amount of water as that of field No. 1 or 2, we would estimate that the amount of water received as seepage was between 3 and 6 inches. The graph for this field shows that the water content of the root zone was within the optimum range throughout the season. On the graph the root zone lies to the right of the dotted line, showing depth of root penetration.

Field No. 4, was located some 25 miles west of field No. 3. It has a soil similar to that of fields Nos. 1 and 2, being a clay loam. Total depth used to grow the crop, 14·2 inches. Low use in this case is due to increase in water content of lower soil zones during September and October from seepage.

Plate No. 12

Field No. 5, used 20·1 inches to grow the crop. It was too wet until about July 20. On August 10 a 3-inch irrigation was applied as the first 2 feet in depth were getting too dry. This field is free from seepage.

Fields Nos. 6 and 7. This is one large field, of which the south half is well drained and on a hillside, and the north half low-lying and subject to seepage water from the south portion. The north half or No. 7 was much too wet all season. It showed a use of 17·0 inches and probably received around 4 inches from below as seepage. The south half or No. 6 showed a slight shortage of water in the first foot between August 1 and September 10, but was too wet, except for the surface foot, up to August 1, it used 19·0 inches during the season. Field No. 7 received considerable seepage water during the rainy period September 6 to 16.

Field No. 8, used 16·6 inches of water to grow the crop. It was much too wet up to August 15, but in fair moisture content after that date. It was not affected by seepage.

Field No. 9, used 15·7 inches of water to grow the crop. The moisture content of this field was good for the greater part of the season, except for the period June 1 to July 15, when it was too wet.

The tables on Plates 11 and 12 show the depth of water used by each field for each month during the growing season. A mean of the 9 fields shows a total use of 17·8 inches to grow the crop. A mean of 3, well drained fields (Nos. 1, 2 and 5) shows a total depth of 20·5 inches used to grow the crop. This agrees very closely with the average depth used to grow the crop as determined on 3 fields at the Brooks Experimental Station in 1927 and shown on Plate 13, i.e. 21·6 inches. A mean of 3 fields affected by seepage (Nos. 3, 7 and 9) shows a total depth of 16·3 inches used to grow the crop. Two factors would tend to make the seeped fields show a lower use than the well drained fields: 1. The seeped fields are colder and not so favourable to plant growth. 2. The seeped fields receive water from below that is not subject to measurement.

Plate No. 13

Plate No. 13 shows the seasonal use of water on 3 fields at the Brooks Experiment Station in 1927. Field No. 48-D is one of high soil fertility, having been in Alfalfa before being cropped to beets. Field 53-A has also been in alfalfa but is not so fertile as 48-D. Field 89, 90-D has the lowest soil fertility of the 3, having grown grain for several years with only an occasional hay grass crop to renew soil fertility. Each of the 3 above noted fields produced the maximum yield per acre in its respective crop series, showing that the moisture content as maintained to a depth of 4 feet during the season was nearer the optimum amount than that of the other 4 fields in each series, which received either more or less water than the maximum producing fields noted above. The table on the diagram shows the amount of water used each month during the

season. The 3 graphs show the moisture content of each field to a depth of 4 feet during the season and its relation to the optimum content as shown by the shaded zone. The date and depth of irrigations is shown by small arrows above the water content line for the first foot.

——	April	May	June	July	Aug.	Sept.	Oct.	Total
Mean of 3 fields at Brooks (48-D, 53-A 8990-D)	0·4	2·2	4·3	8·4	4·1	1·7	0·5	21·6
Mean of 3 well drained fields in Stirling-Magrath district (1, 2, 5)	0·0	2·6	4·0	5·3	5·7	1·7	1·2	20·5

The preceding table shows the amount of water used to grow beets on 3 fields at Brooks in comparison with 3 of the best drained fields in the Magrath-Stirling district. An average of the Brooks fields shows a total use during the season of 1·1 acre-inches more than the average of the Magrath-Stirling fields. The Brooks fields used 8·4 inches of water in July as compared with 5·3 inches at Raymond. The following table compares the conditions in the two districts that influence rate of use of water.

——	Brooks	Magrath-Stirling	Difference
Altitude above sea level	2,500 ft.	3,150 ft.	650 ft.
Mean temperature for season (May to Oct. inclusive)	55·8°	54·0°	1·8°
May and June rainfall	8·2″	10·9″	2·7″
May to October rainfall	16·5″	19·0″	2·5″

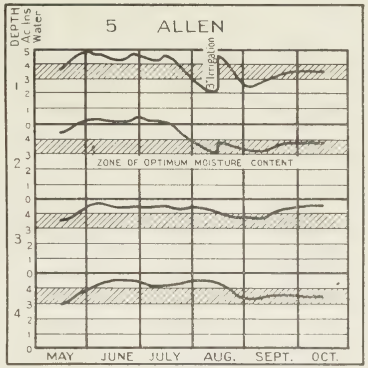
Brooks had the more favourable conditions for growth of the two districts. It had a higher seasonal temperature by 1·8 degree. It lies at a lower elevation by 650 feet and is farther from the mountains and therefore had warmer nights. It had less rainfall and therefore in the months of May and June especially, a warmer soil nearer the optimum water content and better aerated than that of the Magrath-Stirling district. On the Brooks fields 8·4 inches of water was used during July as compared with 5·3 inches on the Magrath-Stirling fields. During this month the mean temperature at Brooks was warmer by 2·8 degrees than that at Magrath-Stirling and the downward root growth about 6 inches greater.

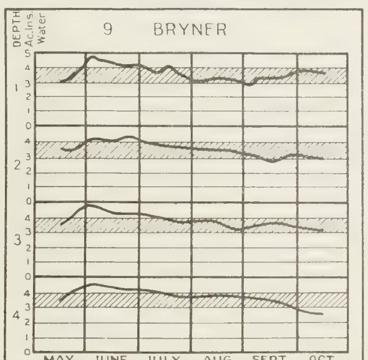
On July 1 the beets at Brooks had developed root systems to a depth of 9 to 14 inches and had top diameters at the crown of around $\frac{3}{4}$ inch. The beets at Magrath-Stirling had developed their root systems to a depth of 4 to 7 inches and had diameters of $\frac{1}{2}$ inch at the crown. The amount of water transpired or used through the plant depends upon the area of its moisture absorbing root surface and upon the area of the leaf surface. The Brooks beets were therefore stronger, larger, and farther developed at the beginning of July than those of the Magrath-Stirling district and needed and could use more water per day during July than the latter. Thus earlier and more extensive plant development and warmer temperature in air and soil account to a large degree for the greater amount of water used by beets at Brooks during the month.

On August 1 Brooks beets had average tap root lengths of 30 inches, while Magrath-Stirling beets had average tap root lengths of 20 inches.

DEPARTMENT OF THE INTERIOR, CANADA
DOMINION WATER POWER AND RECLAMATION SERVICE

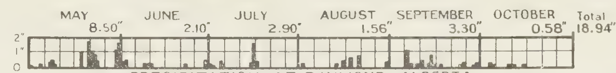
SEASONAL USE OF WATER BY SUGAR BEETS MAGRATH-STERLING DISTRICT, ALBERTA. 1927



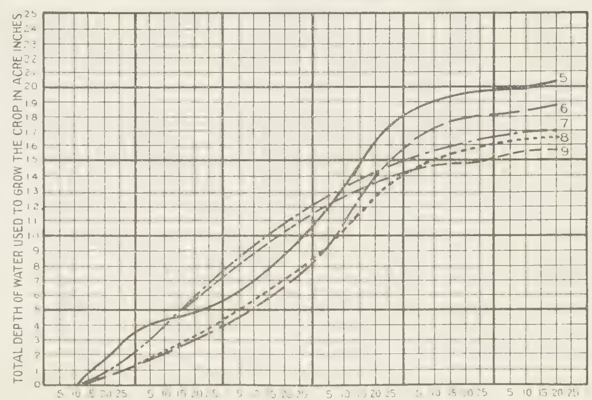


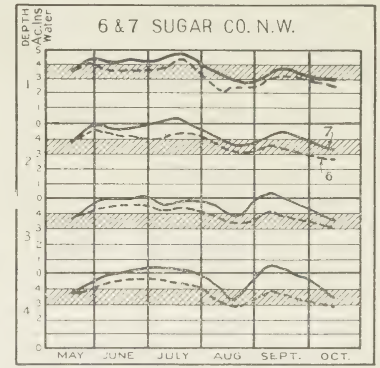
DEPTH OF WATER USED PER MONTH IN ACRE INCHES

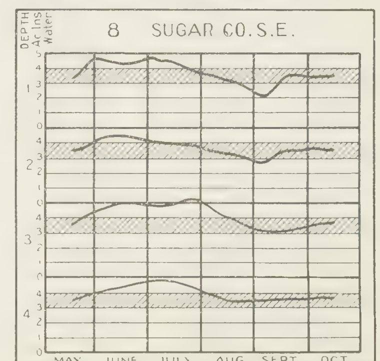
		MAY	JUNE	JULY	AUG	SEPT.	OCT.	TOTAL
5	ALLEN	3.0	2.8	4.8	7.6	1.4	0.5	20.1
6	SUGAR CO. N.W.S	1.2	3.0	4.0	7.6	2.4	0.8	19.0
7	SUGAR CO. N.W.N	2.0	5.0	4.7	3.0	1.8	0.5	17.0
8	SUGAR CO. S.E	1.2	3.2	4.2	5.6	1.8	0.6	16.6
9	BRYNER	2.0	4.8	4.6	2.8	1.0	0.5	15.7
	MEAN	1.9	3.8	4.5	5.3	1.7	0.5	17.7
Mean of fields 1 to 9.		2.1	4.0	4.4	4.8	1.8	0.7	17.8
Mean of well drained fields 1, 2, 5.		2.6	4.0	5.3	5.7	1.7	1.2	20.5
Mean of fields affected most by ground water 3, 7, 9.		6.1	4.8	4.0	3.3	1.6	0.5	16.3



PRECIPITATION AT RAYMOND ALBERTA







The Magrath-Stirling beets made their greatest root and leaf development in August and used an average depth of 5·7 inches as compared with 4·1 inches at Brooks, where the greatest root development occurred nearly a month previous.

Brooks beets used more water in June than those of the other districts for the same reasons as for July growth.

The Magrath-Stirling use is greatest for May due to heavier rainfall and therefore greater percolation and surface run-off losses.

DRAINAGE SURVEYS AND INVESTIGATIONS

Drainage administration during the year 1927-28 has again been mainly confined to the development of smaller schemes. The department, however, has maintained supervision over the Waterhen Lake drainage project in Saskatchewan, the drainage schemes of the Manitoba Dairy Farms Limited in Manitoba, and has also kept in touch with provincial drainage development in the provinces of Saskatchewan and Alberta.

Small Projects

Drainage schemes that may be carried out by private interests are limited in size to 1,280 acres and in cost to $5,000.

In the provinces of Alberta and Saskatchewan there are a great many sloughs and small lakes which, when properly drained, make excellent hay lands and in some cases good agricultural lands. Provision is made under the Drainage Regulations for the reclamation of such lands upon application being made to the department. All such applications are investigated by the department and when schemes are determined to be feasible and economical, surveys are made from which plans are prepared and the applicants allowed to acquire the reclaimed lands either by purchase or supplementary patent, depending upon the nature of the ownership of the remaining quarter sections affected.

The construction of such schemes is yearly adding a considerable area of tillable and fertile land to homesteads in Alberta and Saskatchewan. A feature of this development worthy of note, particularly in the northern parts of the provinces, is the benefit to roads thereby and in the very considerable saving in cost in their maintenance.

During the year 1927-28, owing to an exceptionally late spring and wet fall, there was very little opportunity to construct drainage schemes or to maintain the ditches now in operation with the result that many of the schemes authorized have not yet been completed and in many cases lands which had been almost wholly reclaimed were re-flooded. It is estimated, however, that in the Edmonton district the returns from the small drainage schemes in operation and under construction for the year 1927-28 will be almost 2,500 tons of wild and cultivated hay valued at $10 per ton.

The location of small drainage projects are generally in groups. The development of these groups is the result of the success of a drainage pioneer in a certain district whose methods and example are immediately followed by his neighbours.

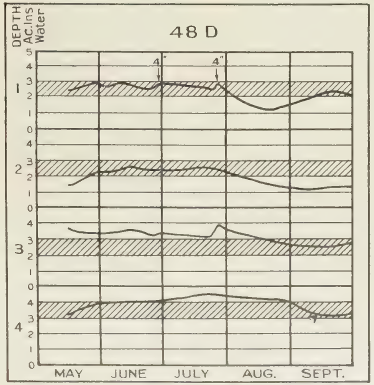
A striking example of the success of small scheme drainage may be cited in the case where in 1927 a crop of Garnet wheat, grade No. 2, that averaged $45\frac{3}{4}$ bushels to the acre was harvested from land which only 3 years before formed the bed of a shallow lake.

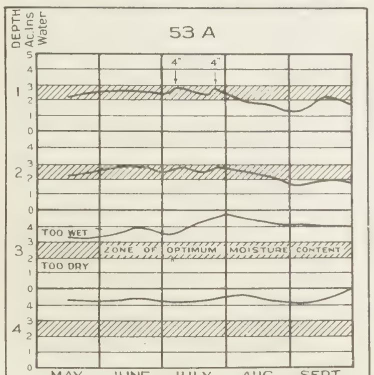
During the past year 88 small drainage schemes were inspected; 21 applications considered; 8 schemes authorized for construction; 10 drainage sales made; and 7 applications cancelled.

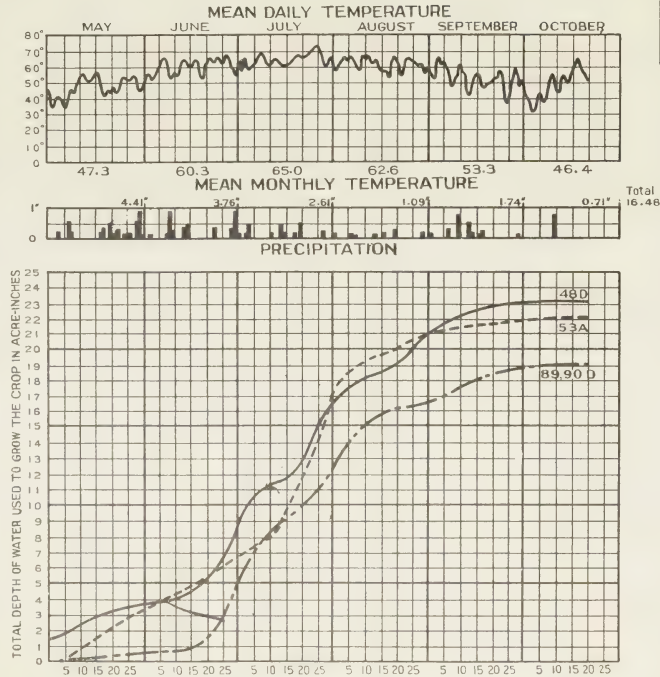
PLATE 13

DEPARTMENT OF THE INTERIOR, CANADA
DOMINION WATER POWER AND RECLAMATION SERVICE

SEASONAL USE OF WATER BY SUGAR BEETS BROOKS, ALBERTA. 1927



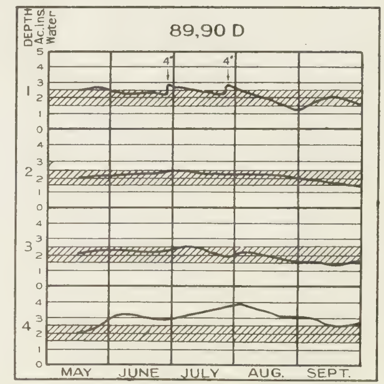




DEPTH OF WATER USED PER MONTH IN ACRE INCHES

	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	TOTAL
48 D	1.3	2.5	5.0	7.8	4.2	2.2	0.2	23.2
53 A	0.0	3.3	3.4	10.3	3.8	0.8	0.8	22.4
90 D	0.0	0.7	4.6	7.1	4.2	2.2	0.3	19.1
MEAN	0.4	2.2	4.3	8.4	4.1	1.7	0.5	21.6

PLOT	TONS OF BEETS	POUNDS OF SUGAR
48 D	17.0	6,090
53 A	15.6	5,300
89,90 D	9.6	3,620



Provincial Drainage Projects

A number of drainage schemes in the provinces of Alberta and Saskatchewan have been authorized by this department. Districts have since been organized and works constructed under provincial drainage laws.

SASKATCHEWAN PROVINCIAL DISTRICTS

During the year 1927-28 considerable progress was made in the development of drainage projects in the province of Saskatchewan. Drainage district No. 27 in the vicinity of Lewvan was completed and work was commenced on the Grand Coulée drainage district. The enlargement and extension of ditch No. 2 in the Riceton Béchard drainage district, No. 13, was also undertaken at an estimated cost of $22,000.

Several sales of Crown lands were held during the year. Five quarter sections were sold at Canora and 3 at Yellowgrass. Additional lands were sold in the Moose Range district making the total in this area 87 quarter sections at an average price of $11.28 per acre.

ALBERTA PROVINCIAL DISTRICTS

No new drainage districts were formed or petitioned for in the province during the year. Considerable activity was displayed, however, in connection with the formation of a drainage district in the vicinity of Big lake to the southwest of Edmonton. At a meeting held in St. Albert during the summer of 1927 it was decided to circulate a petition for the formation of a district to carry out the works as designed by this department some years ago.

The five provincial districts now in operation in Alberta are the Holden, Daysland, Dickson, Hay Lake and Viking. Certain repairs were made to ditches during the year and plans have been made for extensions in some of the districts which it is proposed to carry out next year.

Owing to the abnormal amount of precipitation during the year which kept the lower lands too wet for growth, these districts from an agricultural standpoint were not as successful as in previous years. Freshets during the year also caused some of the ditches to cave in with the result that some lands were flooded during the greater portion of the year.

The control of noxious weeds along the canal banks is becoming a problem for some of the districts and it is proposed that every land owner should be made responsible for the control of weeds along the lateral ditches through his lands, the district being responsible for controlling the weeds along the main canal.

Financially all of the districts are reported to be in a sound condition.

Eight thousand acres of Dominion land included in drainage districts were sold to the provinces of Alberta and Saskatchewan at the rate of one dollar per acre. Under the provisions of the Dominion Drainage Regulations and the provincial Reclamation Acts the provinces resell this land at public auction for the benefit of the settlers in the drainage districts affected.

Waterhen Lake Drainage Project

Frequent and continued rains during spring and early summer resulted in seeding operations being spread over a whole month, i.e. from May 15 to June 15. The wetness of the soil, and the frequent rains which followed seeding produced rapid germination and the various fields showed wonderful promise.

Heavy July and August rains, however, kept the low-lying lands heavy with water, and a large portion of the grain was ruined. Some 60 acres of wheat on

the southern limits of Sections 1 and 2, however, escaped the fate of the other fields, and from this area some very excellent wheat was cut. This grain was considered to be grade No. 2 and was estimated to yield about 20 or 25 bushels to the acre. Some 40 acres of oats and 130 acres of wheat were flooded and were destroyed. Fifty acres of Western rye grass on the southeast quarter of section 12 grew luxuriantly, but, owing to the wetness of the land could not be harvested at the proper time and was allowed to go to seed. Cutting took place later and it was intended to thresh when conveniently possible.

Cultivated hay crops, such as timothy, bromus, red top, sweet clover and Western rye grass grow luxuriantly on this project and good returns can confidently be expected from such crops.

Weeds are still a menace to the lands on this project but much cleaning and burning was done by the lessees last spring which has improved conditions considerably.

The wetness of the season made it impossible to carry on any experimental work in connection with the test plots maintained during the previous season.

Manitoba Dairy Farms Limited, Western Drainage Scheme

The construction of the main drainage ditch of this project was completed in September, 1927. The canal is approximately 9 miles long, 6 feet base width, 18 feet top width and averages 6 feet deep. A ' walking ' dredge was used by the company on the work.

The effect of the ditch in drying out the adjoining land was clearly evident immediately upon its completion. A motor road is being constructed along the side of the ditch from the excavated material.

The company proposes to undertake the construction of the ditches in the southern part of the scheme next season.

Manitoba Dairy Farms Limited, Eastern Drainage Scheme

Application was made to the department by the Manitoba Dairy Farms Limited to lease for reclamation by drainage the vacant and available Dominion land included in townships 1 to 11, ranges 9 to 17, E.P.M.

Field investigations were carried out during the fall and winter seasons just past to determine the feasibility, desirability, nature of timber and soil and other relevant data. The report of the engineers has not yet been submitted. Conferences were held with the drainage officials of the province of Manitoba.

FUR FARMING

Arrangements were completed whereby the department leases to the provinces of Alberta and Saskatchewan Dominion land susceptible of use for fur farming purposes. The land and water areas are leased under a form of licence to the provinces which release the areas in question to applicants under the provincial fur farming regulations. During the past year 11 such licenses were granted covering approximately 16,000 acres. Before a licence is granted by the Department the province must furnish evidence that any riparian land owners affected have given their consent to the scheme.

CLASSIFIED LIST OF PUBLICATIONS

DOMINION WATER POWER AND RECLAMATION SERVICE
ANNUAL REPORTS

Annual Reports previous to 1913 are included with the Annual Report of the Department of the Interior, and can be secured from the secretary of the department.

Annual Reports for the fiscal years ending March 31, from 1914 to 1928, are available for distribution. That for 1924 is the first report combining the activities of the Water Power and Reclamation divisions of the Service.

WATER POWER

(Water Resources Papers)

REPORTS OF SPECIAL OR GENERAL INTEREST

Water Resources Paper No. 2.—Report on Bow River Power and Storage Investigations, Bow River west of Calgary, by M. C. Hendry, chief engineer in charge of surveys. This is a complete study of the Bow river west of Calgary. It deals with meteorological conditions and their effect on run-off and ice formation. Existing and possible power and storage developments, together with maps and plans are appended complete. Published 1914. Out of print.

Water Resources Paper No. 3.—Report on Power and Storage Investigations, Winnipeg River, by J. T. Johnston, chief hydraulic engineer, Dominion Water Power Branch. A complete study based on field surveys and office computations of the Winnipeg River basin; deals fully with history, international considerations, topography, climate, storage possibilities; describes existing and gives preliminary designs and estimates for possible power developments; discusses other sources of power and the power market. Maps, plans and all relevant data are appended. Published 1915. Out of print.

Water Resources Paper No. 5.—Preliminary Report on the Pasquia Reclamation Project, by T. H. Dunn, chief engineer in charge of Reclamation Survey. This is a progress report of investigations carried out to determine the possibility of lowering the level of Cedar lake and its effect in a general scheme for reclaiming the low-lying lands contiguous to the Saskatchewan river in the Pasquia region. Published 1914. Out of print.

Water Resources Paper No. 6.—Report on cost of various sources of power for pumping in connection with the South Saskatchewan Water Supply Diversion Project, by H. E. Kensit. It deals with the problem of power for pumping water from the South Saskatchewan river for the supply of cities and towns in the central portion of South Saskatchewan. Published 1914. Out of print.

Water Resources Paper No. 7.—Report on the Manitoba Water Powers, by D. L. McLean, S. S. Scovil and J. T. Johnston, compiled for the Manitoba Public Utilities Commission. A general survey of the water-power situation in Manitoba, with all available general information and hydrometric data published to date in condensed form concerning the rivers in Manitoba. Published 1914. Replaced by No. 56.

Water Resources Paper No. 10.—General Guide for Compilation of Water Power Reports of the Dominion Water Power Branch, prepared for the guidance of field engineers of the Dominion Water Power Branch, by J. T. Johnston, chief hydraulic engineer. Published 1915. Limited edition.

Water Resources Paper No. 11.—Second Report on the Pasquia Reclamation Project by T. H. Dunn, chief engineer in charge of Reclamation Survey. This is a continuation Report based on further investigations as outlined under Water Resources Paper No. 5 Published 1915. Out of print.

Water Resources Paper No. 12.—Report on Small Water Powers in Western Canada, and discussion on sources of power for the Farm, by A. M. Beale. Part I is a brief description of certain small western water-power developments. Part II gives an analysis of requirements and cost data for the farm power supply. Published 1915. Out of print.

Water Resources Paper No. 13.—Report on the Coquitlam-Buntzen Hydro-Electric Development. A complete description of the project and of the details of construction, with plans, diagrams and illustrations, by G. R. G. Conway, chief engineer of the British Columbia Electric Railway Company, Limited. Published 1915.

Water Resources Paper No. 16.—Water Powers of Canada. A series of five pamphlets in one volume covering the water-power situation in Canada, prepared for distribution at the Panama Pacific Exposition, San Francisco, 1915, by G. R. G. Conway, consulting engineer, Toronto; Percival H. Mitchell, consulting engineer, Toronto; H. G. Acres, hydraulic engineer, Hydro-Electric Power Commission, Ontario; F. T. Kaelin, assistant chief engineer, Shawinigan Water and Power Co., Montreal; K. H. Smith, engineer, Nova Scotia Water Power Commission, Halifax, N.S. Published 1916. Out of print.

Water Resources Paper No. 17.—Canadian Hydraulic Power Development and Electric Power in Canadian Industry, by Charles H. Mitchell, consulting engineer to Dominion Water Power Branch. Part I deals with progress of utilization, features in design, construction and operation specially applicable to Canada. Description of certain typical Canadian water-power developments. Part II analyses the uses, growth and future of electrical power in Canadian industry. Published 1916. Out of print.

Water Resources Paper No. 20.—Report on the Interests Dependent on Winnipeg River Power, with Special Reference to the Capital Invested and the Labour Employed, by H. E. M. Kensit. A detailed study of the industrial growth and future power requirements of the district tributary to the Winnipeg River power sites. Published 1917. Out of print.

Water Resources Paper No. 27.—Directory of Central Electric Stations in Canada to January 1, 1919, compiled by J. T. Johnston, assistant director, Dominion Water Power Branch. Comprises an analysis of the central electric census statistics and a directory of the stations. Published 1919. Out of print.

Water Resources Paper No. 32.—Water Resources Index Inventory, by J. T. Johnston. Description of the Index Inventory System for recording and collating the water resources data of the Dominion. Published 1922. Out of print.

Water Resources Paper No. 33.—Directory of Central Electric Stations in Canada, to November 1, 1922. Comprises an analysis of the central electric station statistics and a directory of the stations. Published 1923. Out of print. Replaced by W. R. P. No. 55.

Water Resources Paper No. 55.—Directory of Central Electric Stations in Canada to May 1, 1928. Published 1929. Price 50 cents.

Water Resources Paper No. 56.—Water Powers in Manitoba. Administration, developed power and available undeveloped power, by C. H. Attwood, district chief engineer. Published 1926.

Water Resources Paper No. 60.—Water Powers of Canada. A general review of the water-power resources of Canada as to investigation, administration, developed power, use of power in industry and available undeveloped power, by J. T. Johnston, Director of Water Power and Reclamation. Published 1927.

SURFACE WATER SUPPLY REPORTS

ATLANTIC DRAINAGE SOUTH OF ST. LAWRENCE RIVER INCLUDING NOVA SCOTIA, NEW BRUNSWICK, PRINCE EDWARD ISLAND, AND SOUTHEASTERN QUEBEC

Water Resources Papers Nos. 29, 37, 45 and 52.—Surface water supply of Canada. Reports on hydrometric surveys covering the Atlantic drainage south of the St. Lawrence river, including Nova Scotia, New Brunswick, Prince Edward Island and southeastern Quebec, for the climatic years ending September 30, 1919 to 1926, by K. H. Smith and K. G. Chisholm, district chief engineers.

ST. LAWRENCE AND SOUTHERN HUDSON BAY DRAINAGE IN QUEBEC

Water Resources Papers Nos. 41, 48 and 58.—Surface water supply of Canada. Reports on hydrometric surveys covering the St. Lawrence and southern Hudson Bay drainage in Quebec for the climatic years ending September 30, 1923 to 1927, by Leo G. Denis, district chief engineer.

ST. LAWRENCE AND SOUTHERN HUDSON BAY DRAINAGE IN ONTARIO

Water Resources Papers Nos. 28, 34, 38, 42, 49 and 58.—Surface water supply of Canada. Reports on hydrometric surveys covering the St. Lawrence and southern Hudson Bay drainage in Ontario for the climatic years ending September 30, 1920 to 1927. by district chief engineers.

ARCTIC AND WESTERN HUDSON BAY DRAINAGE (AND MISSISSIPPI DRAINAGE IN CANADA) IN ALBERTA, SASKATCHEWAN, MANITOBA, EXTREME WESTERN ONTARIO, AND NORTHWEST TERRITORIES

Water Resources Papers Nos. 4, 19, 22, 24 and 26.—Surface water supply of Canada. Reports on hydrometric surveys in Manitoba, from January 1, 1912, to September 30, 1919, by M. C. Hendry and C. H. Attwood, chief engineers. No. 4 contains a gazetteer of lakes and streams in Manitoba.

Water Supply Bulletins Nos. 1 to 11.—Surface water supply of Canada. Reports on hydrometric surveys in Alberta and Saskatchewan from 1908 to September 30, 1919, by P. M. Sauder and A. L. Ford, chief hydrometric engineers, Reclamation Service. Out of print.

Water Resources Papers Nos. 31, 36, 40, 44, 46, 50, 54 and 57.—Surface water supply of Canada. Reports on hydrometric surveys covering the Arctic and western Hudson Bay drainage (and Mississippi drainage in Canada) in Alberta, Saskatchewan, Manitoba, extreme western Ontario and the Northwest Territories, for the climatic years ending September 30, 1920 to 1927, by C. H. Attwood and A. L. Ford, district chief engineers.

PACIFIC DRAINAGE IN BRITISH COLUMBIA AND THE YUKON TERRITORY

Water Resources Papers Nos. 1, 8, 14, 18, 21, 23, 25, 30, 35, 39, 43, 47, 51, 53 and 59.—Surface water supply of Canada. Reports on hydrometric surveys covering the Pacific drainage in British Columbia and the Yukon Territory from May, 1911, to September 30, 1927. No. 1 is by P. A. Carson, chief engineer, the others by R. G. Swan and C. E. Webb, district chief engineers. No. 1 contains an outline of the history of the Railway Belt with special reference to its administrative, legal and physical problems in regard to water, and a gazetteer of the lakes and streams in British Columbia.

MAP

Water Power of the Dominion of Canada prepared in connection with the First World Power Conference, London Eng., 1924.

RECLAMATION

Drainage Regulations.

Irrigation Regulations.

Annual Irrigation Reports.—1894-1911. (Out of print.)

Annual Irrigation Reports.—Calendar years 1912 to 1915. (Out of print.)

Irrigation Surveys and Inspection Report.—Fiscal years 1915-16, 1916-17, 1917-18, 1918-19. (Out of print.)

Annual Report of the Reclamation Service—1919-20, 1920-21, 1921-22, 1922-23.

Annual Report of the Water Power and Reclamation Service—1923-24, 1924-25, 1925-26, 1926-27, 1927-28.

Annual Stream Measurement Reports of Alberta and Saskatchewan.—Water Supply Bulletins Nos. 1-11, 1909-1919. (Out of print.) (Continued in Water Resources Papers Nos. 31, 36, 40, etc.).

Western Canada Irrigation Association Reports.—(1st to 11th Convention, 1907-1917). (Out of print.)

International Irrigation Congress Report (1914).

Bulletin No. 1.—Irrigation in Alberta and Saskatchewan. (Consisting of a Synopsis of the Irrigation Act and its Administration.)

Bulletin No. 2.—Alfalfa Culture. (Out of print.)

Bulletin No. 3.—Climatic and Soil Conditions, C.P.R. Irrigation Block.

Bulletin No. 4.—Duty of Water Experiments and Farm Demonstration Work. (Out of print.)

Bulletin No. 5.—Farm Water Supply.

Bulletin No. 6.—Irrigation Practice and Water Requirements for Crops in Alberta. (Out of print.) Replaced by Bulletin No. 7, in course of preparation.

Pamphlets:

Address by Mr. S. G. Porter—"Practical Operation of Irrigation Works."—Extract from W.C.I.A. Report, 1914.

Address by Dr. Rutherford—"Inter-dependence of Farm and City."—Extract from W.C.I.A. Report 1914.

Address by Mr. Don. H. Bark—"The Actual Problem that Confronts the Irrigator." —Extract from W.C.I.A. Report, 1914.

Address by Mr. Don. H. Bark—"Practical Irrigation Hints for Alberta."—Extract from W.C.I.A. Report, 1915.

Address by Mr. Don. H. Bark—"Alfalfa Growing."—Extract from W.C.I.A. Report, 1915.

"Practical Information for Beginners in Irrigation" (by W. H. Snelson, A.M.E.I.C.).

Water Resources Papers, and Irrigation and Drainage Reports, as listed at the end of this report are issued gratis, with the exception of Water Resources Paper No. 55, for which a charge of 50 cents is made. These can be had on application to the Director of Dominion Water Power and Reclamation Service, Department of the Interior, Ottawa.

DEPARTMENT OF THE INTERIOR, CANADA

HON. THOMAS G. MURPHY, Minister; W. W CORY, C.M.G., Deputy Minister

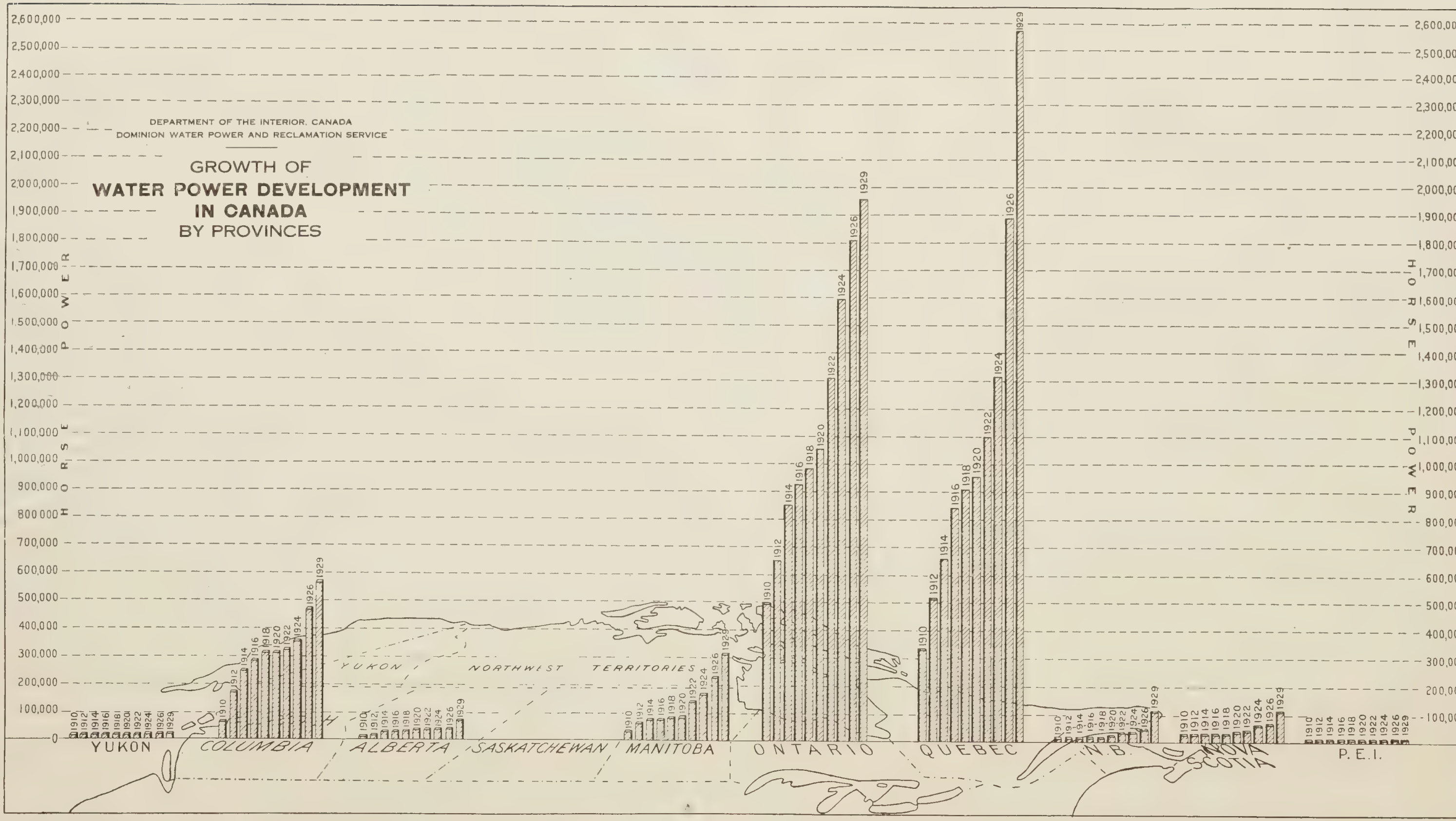
DOMINION WATER POWER AND RECLAMATION SERVICE

J. T. JOHNSTON, C.E., Director

ANNUAL REPORT

1928-29

OTTAWA
F. A. ACLAND
PRINTER TO THE KING'S MOST EXCELLENT MAJESTY
1931


DEPARTMENT OF THE INTERIOR, CANADA
DOMINION WATER POWER AND RECLAMATION SERVICE
GROWTH OF
WATER POWER DEVELOPMENT
IN CANADA
BY PROVINCES
HORSE POWER
YUKON
COLUMBIA
ALBERTA
SASKATCHEWAN
MANITOBA
ONTARIO
QUEBEC
N.B.
NOVA SCOTIA
P.E.I.
YUKON
NORTHWEST TERRITORIES

DEPARTMENT OF THE INTERIOR, CANADA
HON. THOMAS G. MURPHY, Minister; W. W. CORY, C.M.G., Deputy Minister

DOMINION WATER POWER AND RECLAMATION SERVICE
J. T. JOHNSTON, C.E., Director

ANNUAL REPORT

OF THE

DOMINION WATER POWER

AND

RECLAMATION SERVICE

FOR THE

Fiscal Year Ended March 31, 1929

OTTAWA
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PRINTER TO THE KING'S MOST EXCELLENT MAJESTY
1931

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PART III

Reclamation

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Water-power

Reclamation

WATER POWER AND RECLAMATION

INTRODUCTORY

ORGANIZATION

International Waterway Matters.—The organization of the Dominion Water Power and Reclamation Service in field and office is such as to facilitate the ready compilation and analysis of run-off and other hydrometric and hydraulic data on boundary waters and on waters flowing into boundary waters along the international boundary between Canada and the United States. Because of its facilities the service has been charged with the responsibility of securing such data and of making such studies as are necessary for an intelligent consideration of all matters affecting boundary waters, and of advising the Minister with respect thereto.

Water-Power.—The water-power activities are both administrative and investigatory. The proprietary interest of the Dominion in the water resources of Alberta, Saskatchewan and Manitoba, of the Northwest and Yukon Territories and of the Railway Belt in British Columbia gives rise to the necessity of administering these resources in accordance with the Dominion Water Power Act and the Regulations thereunder, and places upon this service the responsibility of securing such fundamental engineering and economic data as will enable it to control properly the development, distribution and sale of hydro-electric energy.

Throughout the rest of Canada the water-powers are vested in the provinces, and investigatory work is carried on in co-operation with the respective provincial authorities charged with the administration of these resources. The service also co-operates extensively with federal departments and commissions other than the Department of the Interior, making the services of its field engineering staff available to these organizations, when, in the interests of general economy and efficiency, it is desirable to do so.

The co-operative water-power and hydrometric survey work is undertaken through district offices, each in charge of a district chief engineer, located as follows: British Columbia, at 739 Hastings street west, Vancouver; Alberta and Saskatchewan, at Southam Chambers, Calgary; Manitoba, at 706 Commercial building, Winnipeg; Ontario, the local organization has headquarters at the Ottawa office of the service; Quebec at 961 Inspector street, Montreal; the Maritime Provinces, at 193 Hollis street, Halifax. In every case the district offices are operated in the closest co-operation with the provincial offices engaged in the administration or use of water or water-power.

In the Yukon and Northwest Territories the water-power resources are administered from Ottawa, and, in the case of the Yukon, through the Gold Commissioner at Dawson. Investigatory work in the Yukon is handled through the British Columbia organization and in the Northwest Territories as the exigencies of the situation demand.

The water-power field organization is based upon and built up around the Dominion Hydrometric Survey staff, through which systematic and continuous stream measurement studies are carried on throughout the Dominion. The data secured by the hydrometric staff and through the co-operative efforts of the various provincial and other organizations are collated, analyzed and standardized at the head office of the service at Ottawa, with the result that there is

already available in Ottawa both general and detailed information concerning the run-off and power possibilities of the more important power rivers throughout Canada. These data are constantly being revised as new or later information is received and are promptly available for reference to all interested in the utilization of the water-powers of the Dominion.

Irrigation and Drainage.—The surface waters in the provinces of Alberta, Saskatchewan, northern Manitoba and the Northwest Territories are administered by the federal Government under the Irrigation Act. All matters that affect the control of water supply generally, as well as the inspection and authorization of works for the use of water for domestic, municipal, industrial and irrigation purposes and the granting of licences for such purposes are dealt with thereunder. Every endeavour is made to administer the water supply so that the greatest benefit may result to the public. The Commissioner of Irrigation at Calgary, Alta., is responsible for all field administration.

The Reclamation Act and Regulations having to do with the reclamation of lands by drainage are administered along similar lines. Any questions of drainage affecting federal interests in the provinces of Manitoba and British Columbia to which the Irrigation Act does not apply, are dealt with through the agency of the district chief engineers of this service in those provinces. Close co-operation is at all times maintained with the provincial drainage authorities.

PUBLICATIONS

A list of the Annual Reports, Water Resources Papers and Reclamation Reports published by this service to date will be found at the end of this report, and copies of those which are still available for distribution will be sent on application to those interested, free of charge, except in the case of the Directory of Central Electric Stations in Canada, for which a charge of fifty cents is made.

During the past year the Annual Report for the fiscal year 1926-27, Water Resources Paper No. 54—Stream Measurements in the Prairie Provinces, and the Interim Report of the Special International Niagara Board, were published.

The Annual Report for 1927-28 and Water Resources Papers Nos. 57 and 58, and the report dealing with evidence to be submitted to the International Joint Commission in connection with the Rainy Lakes Reference, are now in press.

Bulletins were issued dealing with hydro-electric progress in Canada during 1928, the water-power resources of Canada as at January 15, 1929, water-power in the mining industry in Canada dated October 15, 1928, and water-power in the pulp and paper industry in Canada dated December 1, 1928.

PART I

INTERNATIONAL WATERWAY MATTERS

During the year the international waterway problems received continuous attention and appropriate action was taken from time to time in connection with the various matters arising.

Following the submission on December 14, 1927, of the Interim Report of the Special International Niagara Board, appointed by the Governments of Canada and the United States for the investigation into the preservation of the scenic beauty of Niagara falls and an analysis of all factors relative thereto, inclusive of what amounts of water might be permitted to be diverted for power purposes, the board continued its investigatory work at the falls. The interim report recommended the early construction of certain initial remedial works designed to re-water the bared flanks of the Horseshoe falls and to restore and preserve the scenic values of the spectacle as a whole.

Based upon this report a Convention and Protocol was signed between Canada and the United States on January 2, 1929, providing for the construction of remedial works and permitting the concurrent experimental withdrawal of water from the Niagara river additional to the amount specified in the Boundary Waters Treaty of 1909, to the extent of 10,000 cubic feet per second on each side of the river—these additional diversions to be allowed only during the winter or non-tourist season—and the provision for this diversion to terminate seven years from the date of the initial additional diversion authorized.

The objective of the Convention is to demonstrate the effectiveness of remedial works to preserve and enhance the scenic values of the falls and to determine experimentally whether additional withdrawals of water could be permitted without impairment to these scenic values.

The Protocol provides for the construction of the remedial works under stringent conditions of governmental supervision and control, by the Hydro-Electric Power Commission of Ontario and the Niagara Falls Power Company of Niagara Falls, New York. The Convention is now before the legislative bodies of the two countries for ratification.

The suit between the complainant states of Wisconsin, Minnesota, Pennsylvania and Ohio, vs. the Chicago Sanitary District, before the United States Supreme Court in reference to the diversion of water from the Great Lakes system through the Mississippi watershed, has been closely followed in view of its importance to Canadian interests.

Following the submission of Special Master Charles E. Hughes' report to the United States Supreme Court made on November 23, 1927, time was allowed by the court for the filing of exceptions to the Special Master's findings, and following the filing of these, final oral arguments were presented to the Supreme Court on April 23, 1928, and the decision of the court was finally released on January 14, 1929. The court ruled that it was its duty by an appropriate decree to compel the reduction of the diversion to a point where it rests on a legal basis, and thus to restore the navigable capacity of lake Michigan to its proper level. The decision also provided that the Special Master make a further examination into the situation to determine the practical measures needed to give effect to the court's finding and to determine the period required for their completion. The Special Master is authorized to hear witnesses and, with all convenient speed, to make a report of his conclusions, and of a form of decree.

In accordance with these provisions, the Special Master held a hearing in Chicago on March 25 to 29, 1929, at which representations were made by the Chicago Sanitary District and by the complainant states as to the measures which might be taken to reduce the diversion and as to the time involved. A further hearing in this connection is set for April 15, at Washington.

The Lake of the Woods Convention between Canada and the United States executed on February 24, 1925, embodied a number of provisions which require departmental action.

The Convention provides for the securing of a flowage easement up to elevation 1064 on the United States shore of lake of the Woods and accords to Canada the privilege of representation by counsel should the costs be determined by means of the usual judicial procedure in the United States. In accordance with this provision, Canada has been represented by counsel in the proceedings relative to the appointment of appraisers for the evaluation of the lands, in August and September of 1928, and in the subsequent hearings relative to the instructions given to the appraisers at hearings held early in December, 1928, and in February and March, 1929. The appraisers are at the present time engaged in evaluating the first group of claims.

The Lake of the Woods Convention also provided for a reference to the International Joint Commission of the question of storage in Rainy lake and in the boundary waters above and of the development of power in connection therewith. Intensive field and office investigatory work has been carried out in connection with this reference and an interim report has been prepared incorporating the basic data upon which the problem can be properly studied, and is now in the hands of the King's Printer.

The hearing arranged for by the International Joint Commission on the application of the St. Lawrence River Power Company for permission to raise the crest of the company's existing submerged weir in the South Sault channel of the St. Lawrence river near Massena, New York, was held on April 3, 1928, in Washington. The Dominion Government requested that the final hearing of the application be postponed until the middle of June, in order that further study might be given to the situation. The commission directed that the hearing stand adjourned *sine die,* the applicants to have the right to present their application for hearing, such hearing to be held upon due notice to all parties interested at such later date as might be fixed by the commission. No further action has developed to date.

Following the hearing held by the International Joint Commission on November 29, 1927, at Nelson, B.C., in respect to the application of the Creston Reclamation Company for approval of its project for the reclamation by dyking of 8,600 acres of land in Kootenay Flats on the Kootenay river, the commission withheld approval in order to permit of further investigations being made. Following these investigations the commission, on April 3, 1928, issued an order approving the plans and specifications, subject to certain specified conditions. No active construction work has been undertaken to date.

The Roseau river situation has constituted an international problem for some years past. Following several exchanges of views between the two Governments, it was agreed that the entire question should be referred to the International Joint Commission for investigation and report. Accredited representatives of the two Governments accordingly met at Winnipeg on July 10, 1928, and drew up Terms of Reference which, in due course, were referred to the International Joint Commission by the two Governments. A hearing has been arranged to take place before the commission at Roseau, Minnesota, on June 6 next. In the meantime, an intensive field and office study is under way looking to the collection and presentation of the technical data bearing upon the problem,

which must form the basis of the final decision of the commission. In this investigatory work the department is having the close co-operation of the Department of Public Works.

Other problems have been active along the international boundary throughout the year, such as those arising in connection with lake Memphremagog storage, and the Columbia River Reclamation Project in the United States, and its affect upon the Pend d'Oreille river in British Columbia. Consideration is being given to the establishment of international gauging stations on the rivers crossing the international boundary from lake of the Woods to the Pacific coast. Systematic attention has been given to all situations which have arisen and on which action has been required.

The various international waterway boards have functioned as usual throughout the year.

In accordance with the Order issued on October 4, 1921, by the International Joint Commission in conformity with the provisions of the Boundary Waters Treaty of 1909, the measurement and apportionment of the stream flow in the St. Mary and Milk rivers and their tributaries in the provinces of Alberta and Saskatchewan and in the State of Montana, were continued throughout the past year by an engineer of this service in co-operation with an engineer of the United States Reclamation Service. The report covering the year's operations has been prepared and submitted to the commission for review upon the occasion of its regular semi-annual meeting in April.

The Lake of the Woods Convention provided for two boards for the control of the lake levels and the outflow therefrom—the Canadian Board, and the International Board. The Canadian Lake of the Woods Control Board has continued its regulation of lake of the Woods between elevations 1056 and 1061 sea-level datum, as elsewhere recorded in this report. The International Lake of the Woods Control Board is called upon to exercise its responsibilities whenever the lake rises above elevation 1061 or falls below elevation 1056. On June 18 last, owing to heavy precipitation throughout the watershed, the lake level rose above elevation 1061 and the International Board automatically assumed control. The lake continued to rise, reaching a maximum of 1061·31 on July 13, returning to elevation 1061 on August 4, and reverting to the control of the Canadian Board. On September 15 the lake level again rose to elevation 1061, rising to 1061·23 by October 15, and remaining under the control of the International Board until November 9, when the level again fell below elevation 1061.

Under the Convention the International Board is also charged with the responsibility of approving certain protective measures to be constructed on the United States shore of the lake. On May 8, 1928, the board approved the protective works planned for the town of Warroad. Other lesser works have also received the board's approval.

The International Lake Superior Board of Control continued to exercise its responsibilities with respect to the regulation of lake Superior throughout the year. Records of discharge through the rapids, navigation canals and powerplants on both sides of the river were systematically reported to the board. The work of recalibrating the sluices of the control dam and of the other outlets was continued. The improvement in lake levels arising from the increased precipitation through the Great Lakes watershed, continued in 1928 and by the month of August the lake had risen to elevation 603·0 sea-level datum. The lake elevation was at 602·55 on March 31, 1929, and the mean discharge for the fiscal year was 74,000 cubic feet per second, or about 10,000 cubic feet per second greater than the mean for the fiscal year ending March 31, 1928.

The International Niagara Board of Control has continued its close regulation of the diversions from the Niagara river for power purposes as permitted by Article 5 of the Boundary Waters Treaty. Continuous records of the with-

drawal of water by all power-stations on both sides of the river are obtained by the board and the control exercised is such as to ensure that the limits of the diversion set forth in the treaty are not exceeded.

The International Massena Board of Control continued to exercise its supervision over the conditions obtaining with respect to the submerged weir in the South Sault channel of the St. Lawrence river and the regulation of flow through the Massena canal, in accordance with the order of the International Joint Commission dated December 6, 1922. The board was in receipt of monthly reports showing the amount of water diverted and the power-house performance from day to day. No abnormal conditions developed during the year. The mean daily diversion exceeded 25,000 cubic feet per second on four days. The elevations of the river at Lock 21 were improved by the operation of the submerged weir, the increased height of the water surface above the natural conditions varying from 0·30 to 0·83 foot, thus improving navigation conditions.

The International St. Croix River Board of Control continued to exercise its supervision over discharge of the St. Croix river past Grand Falls dam, in accordance with the orders of the International Joint Commission, dated November 9, 1915, and October 3, 1923. The board was in receipt of regular reports of the discharge of the river and of the water elevations above and below the Grand Falls dam. No abnormal conditions developed during the year. General satisfaction with the regulation was expressed by the officers in charge of the power-stations below the dam, while the supply of water for fishway operation was at all times satisfactory.

PART II

LAKE OF THE WOODS CONTROL BOARD

The Canadian Lake of the Woods Control Board was first formed under authority of Dominion Order in Council, P.C. 150, dated January 21, 1919, and consisted of four qualified civil engineers, two appointed by that Order in Council to represent the Dominion and two appointed by an Order of the Executive Council of Ontario, dated February 13, 1919, to represent the province of Ontario. The responsibilities of the board were concerned with the regulation of the levels and outflow of lake of the Woods.

At a conference of representatives of the Dominion Government, and the provinces of Ontario, and Manitoba, held in Ottawa on January 31, 1921, it was unanimously agreed that concurrent legislation should be enacted by the Dominion and the province of Ontario to set up a Lake of the Woods Control Board with authority to control all existing and prospective structures in the waters of the Winnipeg and English rivers in the province of Ontario. The Dominion enactment of the concurrent legislation, designated *The Lake of the Woods Control Board Act, 1921,* was accordingly passed by the Parliament of Canada on May 3, 1921, but, owing to lack of support, the corresponding provincial legislation was withdrawn in the Ontario Legislature.

The activity of certain power proposals on the Winnipeg river made it essential that there should be full legislative authority behind the Control Board and to meet the situation which had arisen *The Lake of the Woods Regulation Act, 1921,* was passed by the Parliament of Canada on June 4, 1921. This latter Act declared all existing and prospective works and structures in the Winnipeg and English rivers, which affected the flow or natural levels of these waters, to be for the general advantage of Canada. It made no change in the control of the power resources. The Act provided that the Governor General in Council might make and enforce such regulations as he might consider necessary, for securing the most dependable flow of the Winnipeg and English rivers; for regulating the level of Lake of the Woods as recommended by the International Joint Commission; and for regulating the level and outflow of lac Seul. The Act also provided that the Governor General in Council should have power to appoint a board to aid in the administration and enforcement of the provisions of the Act, and that he might repeal or suspend that Act should the concurrent legislation (as previously referred to) be passed by the Ontario Legislature.

Pursuant to the *Lake of the Woods Regulation Act, 1921,* Order in Council, P.C. 3523, dated September 21, 1921, was passed by the Dominion Government authorizing that the four members of the original board be re-appointed in their same capacities. This Order in Council charged the Lake of the Woods Control Board with the responsibility of the administration and enforcement of the provisions of the *Lake of the Woods Regulation Act, 1921,* and the preparation for the approval of the Governor in Council of such regulations as the board might from time to time consider necessary to carry out the provisions of the said Act.

On June 13, 1922, the Province of Ontario passed the *Lake of the Woods Control Board Act, 1922,* being the concurrent legislation hereinbefore mentioned, with a provision to the effect that it should not come into force until the repeal by the Parliament of Canada of the *Lake of the Woods Regulation Act, 1921.*

Early in 1928, an agreement was made between the Dominion of Canada, the Provinces of Ontario and Monitoba, to provide storage on lac Seul. This agreement was confirmed by the Dominion by the enactment of the *Lac Seul Conservation Act, 1928,* passed by the Parliament of Canada on June 11, 1928, which Act also provided for the repeal of the *Lake of the Woods Regulation Act, 1921,* on the day upon which the Lieutenant Governor of the province of Ontario should bring into force by his proclamation the *Ontario Lake of the Woods Control Board Act, 1922.* The agreement was similarly confirmed by the province of Ontario in the passing of the *Ontario Lac Seul Conservation Act, 1928.*

As provided by the *Dominion and Ontario Lac Seul Conservation Acts, 1928,* proclamations were issued by the Governor General and the Lieutenant Governor of Ontario which had the effect of repealing the *Lake of the Woods Regulation Act, 1921,* and bringing into force the *Dominion Lake of the Woods Control Board Act, 1921,* and the *Ontario Lake of the Woods Control Board Act, 1922, i.e.* the concurrent legislation, all to take effect as from June 30, 1928.

This concurrent legislation thus forms the existing statutory authority for the joint regulation of the Lake of the Woods and the Winnipeg and English rivers. It provides that there shall be a board to be called " The Lake of the Woods Control Board " which shall consist of four members, who shall be duly qualified engineers, two of whom shall be appointed by the Governor General in Council and two of whom shall be appointed by the Lieutenant Governor of Ontario in Council, and that it shall be the duty of the board to secure severally and at all times the most dependable flow and the most advantageous and beneficial use of the waters of the Winnipeg and English rivers. The legislation provides that for these purposes the board shall have the power to regulate and control the outflow and levels of lake of the Woods as recommended by the International Joint Commission; to regulate and control the outflow and levels of lac Seul in such manner as the Governor General in Council and the Lieutenant Governor in Council may determine; and to regulate and control the flow of the Winnipeg river between its junction with the English river and lake of the Woods, and also the flow of the English river between its junction with the Winnipeg river and lac Seul.

The Lake of the Woods Control Board had continued to function under the authority of the *Lake of the Woods Regulation Act, 1921,* but under the new legislation it was necessary to re-appoint the members of the board. Accordingly, Dominion Order in Council, P.C. 1047, dated June 20, 1928, authorized the appointment of the Director of the Dominion Water Power and Reclamation Service and the Chief Engineer of the Department of Public Works as the two members to represent the Dominion Government on the board, and an Ontario Order in Council, dated June 27, 1928, authorized the appointment of two members to represent the province of Ontario on the board.

For the proper performance of its duties the board is to a large extent dependent upon the collection of hydrological and meterological data relating to the watershed and the board is now deriving the benefit of comprehensive basic records which have been gathered by the Dominion officials over a period of years.

The *Lake of the Woods Convention and Protocol* between His Britannic Majesty in respect of the Dominion of Canada, and the United States, for regulating the level of lake of the Woods, signed at Washington, February 24, 1925, provides in Article 3, that the Government of Canada shall establish a Canadian Lake of the Woods Control Board and that there shall be established and maintained an International Lake of the Woods Control Board composed of two engineers, one appointed by the Government of Canada and one by the Gov-

ernment of the United States, and that whenever the level of the lake rises above elevation 1061 sea-level datum or falls below elevation 1056 sea-level datum the rate of total discharge of water from the lake shall be subject to the approval of this International Board. The Director of the Dominion Water Power and Reclamation Service was appointed as the Canadian member of the International Lake of the Woods Control Board under authority of Order in Council, P.C. 1516, dated October 1, 1926.

Lake of the Woods Regulation.—During the fiscal year the inflows to Lake of the Woods were above normal and the board was compelled to maintain outflows greater than normal in order to hold lake level below the upper storage limit and to provide storage capacity to handle the annual spring freshets. Lake level was drawn down to elevation 1059·90 on April 27, 1928, and, due to heavy precipitation over the watershed, rose above elevation 1061·00 on June 18. By virtue of the provisions of the Lake of the Woods Convention, the regulation of the lake on reaching this elevation automatically passed into the hands of the International Lake of the Woods Control Board. Lake level was drawn below elevation 1061·00 on August 4, but rose above elevation 1061·00 on September 15, and was again drawn below elevation 1061·00 on November 9. Close cooperation was maintained between the Canadian and the United States members of the International Board, and Dominion officials continued to operate the control structures at the lake outlets under the International Board's supervision. At no time during the fiscal year was the lake level allowed to rise appreciably above the upper storage limit of elevation 1061·25 and this was effected without causing undue inconvenience to interests on the Winnipeg river or at the lake outlets. Considerable excess water was wasted during the winter with a view to providing a safety margin of storage capacity to handle possible high spring inflows. On March 31, 1929, lake level was at elevation 1059·75 and there was no indication of a recurrence of flood conditions.

Throughout the fiscal year the board was indebted to the Department of Public Works for run-off records on Rainy and Namakan lakes, and to the Dominion Meteorological Service and the United States Meteorological Service for precipitation records at the numerous stations throughout the watershed.

Lac Seul Regulation.—As heretofore stated, the *Lac Seul Conservation Acts 1928,* confirmed the agreement made between the Dominion Government, the Ontario Government and the Manitoba Government on February 28, 1928, and became effective on June 30, 1928. This agreement provided for the construction of the Lac Seul Conservation Dam by the Ontario Government. Construction work on the dam was started immediately and the structure was practically completed on March 31, 1929.

WATER POWER REGULATIONS AND LEGAL RESEARCH

Two amendments were made to the Dominion Water Power Regulations by Order in Council of September 10, 1928, one dealing with certain conditions to be observed in the revision of rentals and the other requiring that current rates of wages must be paid to all those employed in the construction, operation and maintenance of works authorized by licence. Interim licences under the regulations were issued authorizing the development of Seven Sisters falls on the Winnipeg river in Manitoba, Island falls on the Churchill river in Saskatchewan and the Ghost-Radnor site on the Bow river in Alberta. The works thus authorized are designed to have, when completed, a total installed capacity of 345,000 horse-power.

The study of Dominion and provincial legislation and jurisprudence relating to the uses of water has been continued, and a large amount of material compiled in recent years was supplied to the Department of Justice in connection with the recent Water-Power Reference before the Supreme Court of Canada.

BRITISH COLUMBIA ADMINISTRATION

The Railway Belt Water Act, under which the Dominion waters in the Railway Belt of British Columbia are administered by the provincial authorities, was amended in 1926 to enable the administration to be conducted in conformity with the most recent provincial Water Acts and some further amendments were made for that purpose in 1928, chapter 6 of that year.

The examination of all water rights granted by the province in the Railway Belt has been continued for the protection of Dominion interests, and the District Chief Engineer at Vancouver has kept in close touch with the proposals of the Westminster Power Company on the Mesliloet river and its tributaries, and the plans and construction operations of the Western Power Company of Canada at Ruskin on the Stave river. Applications for water records have been prepared on behalf of the Department Indian Affairs in connection with the improvement of Indian reserves throughout the province and surveys and investigations made as required. Assistance has also been given in connection with the adjudication by the Board of Investigation under the Water Act on Indian claims to the use of water.

ENGINEERING CO-OPERATION WITH DEPARTMENT OF INDIAN AFFAIRS

In Ontario an inspection was made of the conditions above the power-dam at the Indian school near McIntosh and plans and estimates prepared for the water supply and sewage plans for the Cecilia Jeffrey Indian school near Kenora, work on which is now under way. In Manitoba an extension was made to the sewage system at Sandy Bay school on lake Winnipeg. In Saskatchewan the water supply system for the Guy Indian school near Sturgeon Landing was repaired; water supply and sewage systems were constructed under contract for the Onion Lake School north of Lloydminster at a cost of $17,500; and an inspection made and report prepared on necessary repairs to the water supply for the Indian hospital at Ile a la Crosse.

In British Columbia a large number of investigations were made and construction projects supervised in connection with irrigation and other improvements for the benefit of Indian reserves, schools and villages. The investigations made numbered 36, of which 17 were for irrigation schemes and improvements; water supply, 8; sewerage, 1; water rights, 2; electric light and power, 2; miscellaneous, 6. There were 17 separate construction projects under the supervision of local staff, not all of which were completed at the end of the fiscal

year. Of these 9 were irrigation and storage projects, 5 water supply, 1 sewerage, and 2 for electric light and power. The total cost of these improvements was about $38,000.

A further description of this co-operative work will be found in the separate reports of the District Chief Engineers for the western provinces.

WATER RESOURCES INDEX INVENTORY

The index inventory system for recording and collating the water resources data of the Dominion has been in actual use for a number of years and has provided a most efficient method for the referencing, analysis, standardization, and filing of all data relating to the subject of water resources. A detailed description of the system has appeared in the Annual Report for 1916-17 and in the combined reports for the years 1917-18-19.

The system has been applied to practically all phases of the work carried on by the service, among the more outstanding of which may be mentioned the complete census of developed water-power, the analysis of central electric station activities, undeveloped water-power resources, stream measurement activities, and storage investigations.

This work has been largely carried on in co-operation with provincial organizations, notably the Hydro-Electric Power Commission of Ontario, the Quebec Streams Commission, the British Columbia Water Rights Branch, the Nova Scotia Power Commission, and the New Brunswick Electric Power Commission. The data compiled are being continually revised in accordance with the most up-to-date information and, resulting from a number of years of effort, a very large amount of information in standardized form is now available.

WATER POWER RESOURCES OF CANADA

For a number of years past this service has made a practice of making an annual inventory of Canada's water-power resources in order that reliable information concerning the total available and developed water-power of the country may be kept thoroughly up-to-date and available for public reference.

While complete data regarding Canada's great water-power resources are not yet available, a great quantity of reasonably accurate, together with much specific data, has been collected. All existing stream-flow and power-data available from federal, provincial and private sources have been systematically collated, analyzed and co-ordinated with a view to presenting a dependable estimate of available power based on uniform methods of computation and arrangement. The most recent figures for the Dominion indicate the total resources to be 20,197,000 horse-power under conditions of ordinary minimum flow or 33,113,200 horse-power ordinarily available for six months of the year. These figures are of course subject to revision as more and more is learned of the flow characteristics and physical conditions of the streams throughout the country.

Basis of Computation

The figures for available water-power listed in Table 1 are based upon rapids, falls and power-sites of which the actual existent drop or the head possible of concentration, is definitely established or at least well authenticated. Many rapids and falls of greater or lesser power capacity are scattered on rivers and streams from coast to coast which are not as yet recorded, and which will only become available for tabulation as more detailed survey work is undertaken and completed. This is particularly true in the relatively unexplored northern districts. Nor is any consideration given to the power concentrations which are

feasible on rivers and streams of gradual gradient, where economic heads may be created by the construction of power-dams, excepting only at such points as definite studies have been carried out and the results made matters of record.

In brief, the figures hereunder are based on definite rapids, falls and power sites, and may be said to represent the *minimum water-power possibilities of the Dominion.*

The power estimates have been calculated on the basis of 24-hour power at 80 per cent efficiency for conditions of "Ordinary Minimum Flow" and "Ordinary Six Months Flow." The "Ordinary Minimum Flow" is based on the averages of the flows for the two lowest periods of seven consecutive days in each year, over the period for which records are available. The "Ordinary Six Months Flow" is based upon the continuous power indicated by the flow of the stream for six months in the year. The actual method to determine this flow is to arrange the months of each year according to the day of the lowest flow in each. The lowest of the six high months is taken as the basic month. The average flow of the lowest seven consecutive days in this month determines the ordinary six months flow for that year. The average of such figures for all years in the period for which data are available is the ordinary six months flow used in the calculation.

Estimates of power on the basis of ordinary six months flow are made upon the assumption that it is good commercial practice to develop wheel installation up to an amount, the continued operation of which can be assured during six months of the year with the deficiency in power during the remainder of the year provided from storage not yet created or by the installation of fuel-power plants as auxiliaries. The correctness or otherwise of this assumption for any particular site can only be definitely settled by careful consideration of all circumstances and conditions pertinent to its development. The method, however, enables a fairly satifactory overall estimate of the maximum hydraulic power available, to be made as distinctive from the estimated ordinary minimum power available.

TOTAL AVAILABLE AND DEVELOPED WATER POWER

The most recent analysis of the available and developed water-power throughout the Dominion is summarized by provinces in Table I which shows the known available water-power from all sources and within the limitations outlined in the table as 20,197,000 horse-power for conditions of ordinary minimum flow and 33,113,200 horse-power ordinarily available for six months of the year. While the latter figures may be taken as indicating approximately the commercial capacities of the various sites on the assumption that any deficiency in flow for the remaining six months of the year may be made up either from the storage of excess waters or by the installation of auxiliary fuel power equipment their extreme conservation is evidenced by a study of the developed water-power plants scattered from coast to coast for which complete data as to turbine installation and satisfactory data as to stream flow are on record. Comparison of the corresponding figures of six months flow at these sites with those of actual turbine installation shows the turbine installation to be 30 per cent in excess of the six months flow figure and this has proved to be good commercial practice. Applying this excess percentage to the figures of six months flow power quoted above indicates that the present recorded water-power resources of the Dominion will permit of a turbine installation of approximately 43,000,000 horse-power.

As the total installation to date is 5,349,232 horse-power it is evident that a little less than 12½ per cent of the at present recorded water-power resources of the Dominion are developed.

CURRENT PROGRESS IN DEVELOPMENT

During the year the water-wheels or turbines actually installed and brought into operation totalled slightly more than 550,000 horse-power, bringing the total installation in the whole Dominion to a figure of 5,349,232 horse-power. Additional to this large increase there were many large undertakings under active construction, some of which were nearing completion at the end of the year while others were in their initial stages. The combined installations of these projects total to more than 1,200,000 horse-power. There are also many large developments in prospect, a number of which will undoubtedly be undertaken in the coming year.

The effect upon the country's prosperity of this great program of construction work is evident when it is stated that for the actual development, transmission and distribution of the new power capacity installed in 1928, together with that at present actively under construction, not less than $330,000,000 will be required. Moreover, it has been estimated that for every dollar so expended six dollars are required to apply this power to its ultimate uses so that on this basis, a total expenditure of probably $2,300,000,000 will result throughout the Dominion as a result of this new development.

During 1928 every province was represented in the year's activities and, while Quebec stood first in works of magnitude, the widespread nature of development is perhaps the most interesting and significant feature. Saskatchewan appears for the first time with a hydro-electric project under way on the Churchill river for the supply of the new northern mining area, while British Columbia, Alberta, Manitoba, Ontario and the Maritime Provinces are all represented with important new undertakings or substantial additions to existing developments. The principal activities in each of the provinces are given in some detail in the following paragraphs.

British Columbia.—In British Columbia new water-power equipment to the extent of 79,560 horse-power was installed during 1928, while projects actually under construction or in early prospect involve installations which will ultimately add more than 350,000 horse-power to the province's total.

The West Kootenay Power and Light Company, Limited, practically completed its 75,000-horsepower development at South Slocan on the Kootenay river. The three turbines of 25,000 horse-power were in place and the plant went into operation on December 7 with two units, while the third generator will probably be ready to operate about July 1, 1929. The output from this plant will be added to that from the other two plants of the company on the same river to serve the mining industry of the Rossland district. The company also completed a new outdoor switching station capable of taking care of 150,000 horse-power and constructed a 60,000-volt transmission line, 30 miles in length from Bonnington to Ymir.

To supply the rapidly growing demand in this area the same company has made application to the provincial authorities for the right to develop power on the Pend d'Oreille river, 80,000 horse-power being spoken of as the installation proposed.

The British Columbia Power Corporation has been very active throughout the year in carrying on development work through its subsidiary companies.

Of these the Burrard Power Company, Limited, brought into operation on May 15 the Alouette plant of 12,500 horse-power which had been installed in 1927 and was noted in the review for that year. This plant is automatically operated from the Stave Falls station.

The Bridge River Power Company made good progress on the driving of the two and a half mile tunnel which will bring the waters of Bridge river through the mountain divide to the power station on Seton lake. It is antici-

pated that the initial installation of two 28,000-horsepower generating units will be completed by the end of 1931. The ultimate designed capacity of this development is 300,000 horse-power or more.

The Vancouver Island Power Company carried forward work on the enlargement and improvement of its Jordan River undertaking which, when completed, will include the installation of a 2,250-horsepower automatically operated plant situated at the existing diversion dam on the Jordan river.

Other activities during the year included the virtual completion of the initial stage of Shuswap Falls development of the West-Canadian Hydro-Electric Corporation on the Shuswap river with one unit of 3,800 horse-power. This power will be delivered to Vernon over a 33,000-volt transmission line. The Cork Province Mines installed 435 horse-power on Keen creek for use in the mines, while the Whitewater Mines Limited completed a 280-horsepower development on Whitewater creek also for mining purposes. A small installation of 45 horse-power was made on Stein river for a private estate near Lytton and the city of Nelson engaged in the addition of a 3,000-horsepower unit to its plant at Upper Bonnington falls on the Kootenay river which is expected to be ready for operation in May, 1929.

Among projected developments the East Kootenay Power Company is undertaking immediately the investigation of a 15,000-horsepower scheme at Phillip's canyon on the Elk river for which it has recently been granted an authorization by the provincial authorities. Other mooted projects include a development on the Nimpkish river by the Canadian Forest Products Limited, one on the Campbell river by the Canadian Crown Williamette Company Limited and one at Stamp falls on the Stamp river by the Wilson Syndicate.

The Water Rights Branch of the Provincial Department of Lands carried out an extensive program of preliminary hydro-electric power investigations in some of the more isolated sections of the province, including surveys of powers on such rivers as the Skeena, Bulkley and Chilco.

Alberta.—In Alberta the Calgary Power Company, in the late summer, commenced the construction of a development at the Ghost site on the Bow river about thirty miles west of Calgary. This plant will have an installation of two 18,000-horsepower units and the dam which is being erected will provide a head of 105 feet and pondage of 45,000 acre-feet. Excellent progress was made in the construction program up to the end of the year and it is expected the plant will be ready for operation by November, 1929.

In addition to this new development work the company extended its transmission lines both northerly in the Red Deer district and southerly in the Lethbridge district.

Saskatchewan.—An interesting feature of this review is the inclusion for the first time of the province of Saskatchewan in hydro-electric activity. The Churchill River Power Company, Limited, a subsidiary of the Hudson Bay Mining and Smelting Company, has secured a licence to develop the Island Falls site on the Churchill river in the northern part of the province, the power from which will go to supply the needs of the Flin Flon mine, the property of the parent company. With the completion of the railway from the Pas to the mine, equipment and supplies are now being delivered and these will be carried to the power site on winter roads. Camp buildings are already under construction, a temporary saw-mill is in operation at Island falls and a temporary hydro-electric development of 2,000 horse-power is being built to supply power during construction. The Island Falls power station is designed to include six units of 14,000 horse-power each, three of which it is expected will be in operation before the end of 1930. A transmission line some 65 miles in length will carry this power to Flin Flon.

Another matter of outstanding interest in the province was the submission to the Saskatchewan Government of the report of the Saskatchewan Power Commission favouring a policy of government ownership and operation of power utilities in the southern part of the province. The report proposed that the government acquire by purchase the municipal power plants at Regina, Moose Jaw and Saskatoon, which, operated under a central administration, would form the nucleus of an ultimate provincial system. The Government has announced a power policy based on this report and as a start is negotiating with the city of Saskatoon for the purchase of the city's power plant.

Manitoba.—The year was one of outstanding note in Manitoba as it saw the completion of one large plant and the initiation of two others on the Winnipeg river.

The Manitoba Power Company completed the installation of units Nos. 5 and 6 in its Great Falls station, each of 28,000 horse-power, thus bringing the plant to its ultimate designed capacity of 168,000 horse-power. Unit No. 5 was placed in operation on August 27 and unit No. 6 on November 5. The company also carried out considerable work in the placing of material on the upstream face of the Great Falls rock-fill dam to render it water-tight.

The Manitoba Power Commission which serves numerous municipalities with power in the southern part of the province erected 39 miles of transmission lines during the year and added the town of Winkler to its system.

To meet the rapidly growing power demand on its system the Winnipeg Electric Company through a subsidiary "The North Western Power Company" carried out preliminary work in connection with the development of the Seven Sisters site on the Winnipeg river. A railway 12 miles in length was completed from Whitemouth on the Canadian Pacific Railway to the site and camp buildings were constructed. The power station is designed for an ultimate installation of 6 units of 37,500 horse-power each under a head of 66 feet, making a total capacity of 225,000 horse-power. It is planned to carry forward the work on this development with the greatest expedition in order to have the initial installation of three units in operation under partial head before the end of 1930. A double circuit steel tower 110,000-volt tranmission line of about 75 or 80 miles in length will be built southerly and westerly from the plant to Winnipeg.

The city of Winnipeg Hydro-Electric System is also in need of a supply of power additional to that furnished by its 105,000-horsepower development at Point du Bois on the Winnipeg river and, following an overwhelming endorsement by the ratepayers of the city at the municipal elections in November, work has been initiated in the development of the Slave Falls site about six miles down-stream from Point du Bois. The Slave Falls power station will ultimately contain 8 units each of 12,500-horsepower capacity or a total of 100,000 horse-power. Four transmission-line circuits supported by two lines of towers will transmit the power from Slave falls to Winnipeg. The estimated capital cost of the plant and transmission line is about $10,500,000 and the construction program contemplates the completion of the initial development of two units in 1931.

For the further regulation of the flow in the Manitoba reach of the Winnipeg river an arrangement was made early in the year between the Dominion Government and the Government of the province of Ontario whereby a storage dam is being built by the Ontario Government at the outlet of lac Seul, the cost of which is being shared between the Dominion and Ontario. The storage thus provided, together with that on lake of the Woods, will ensure a dependable flow of 20,000 cubic feet per second on the Manitoba reach of the river. It is expected that the dam will be finished in May 1929.

Ontario.—In Ontario the outstanding event of the year was the completion and the bringing into operation on October 1 of the 220,000-volt transmission line between the Ottawa river and Toronto, over which power purchased from Gatineau Power Company is brought to augment the supply of the Niagara system of the Hydro Electric Power Commission of Ontario. The initial load carried by this line was 80,000 horse-power and the contract calls for an ultimate supply of 260 000 horse-power. The commission also completed the construction of a new 110,000-volt line leading from the Ottawa river near Ottawa to Smiths Falls and Brockville to supply Ottawa and its Eastern Ontario system. The power for this line is also secured from Gatineau Power Company, the contract calling for delivery of 60,000 horse-power with an additional 40,000 horse-power in reserve at the call of the commission. The line was placed in operation late in November with an initial load of 6,000 horse-power.

Other activities of the commission included the construction of an 1,800-horsepower development to serve the Nipissing system at Elliott Chute on the South river, which will be placed in operation in the spring of 1929, and a 2,200-horsepower development at Tretheway falls on the South Muskoka river to augment the supply of the Georgian Bay system. The latter is also expected to be ready for operation in the spring of 1929. In early prospect is the addition of the tenth unit of 58,000 horse-power at the Queenston development and resumption of work at the 54,000-horsepower plant at Alexander Landing on the Nipigon river which it is expected will be placed in operation in 1931. Studies have also been continued in connection with development on the Musquash river for the further supply of the Georgian Bay system and it is possible a start may be made in 1929. The commission is also supervising the construction of the dam at the outlet of lac Seul which has already been mentioned in the Manitoba section. In addition to providing storage for the benefit of the English and Winnipeg river powers, facilities for the development of power will also be provided at the dam itself which is of potential interest to the nearby Red Lake mining district.

Apart from the activities of the commission, hydro-electric development has been actively carried forward by other interests. At Smoky falls on the Mattagami river the Spruce Falls Company completed and brought into operation a 56,250-horsepower development, the power from which is carried over a 50-mile transmission line to the Company's pulp and paper mill at Kapuskasing. The Ontario and Minnesota Power Company completed its Calm Lake development on the Seine river in June with an installation of 13,200 horse-power. This power is brought to Fort Frances for use in the pulp and paper industry. The Dryden Paper Company completed and placed in operation in October a 2,000-horsepower development on the Eagle river, while the International Nickel Company carried forward the construction of a 28,200-horsepower development at the Big Eddy dam on the Spanish river which is expected to be ready for operation early in 1929.

Quebec.—New plants and extensions to existing plants actually placed in operation during 1928 added more than 300,000 horse-power to Quebec's hydro-electric installation; this additional capacity being mainly found in the new Paugan plant of the Gatineau Power Company (a subsidiary of the Canadian Hydro-Electric Corporation, Limited, the Canadian power unit of the International Paper and Power Company) and, in additional units installed at the plants already in operation at Shawinigan, at Isle Maligne, and Quinze Dam.

The Paugan plant of the Gatineau Power Company was placed in operation with six units in September 1928; each unit is of 34,000 horse-power giving a present installation of 204,000 horse-power, while two additional units are provided for, which will bring the ultimate capacity of this station to 272,000 horse-

power. The same company is also installing a fourth unit in each of the other two plants lower down on the Gatineau river, the capacity of these additional units being 34,000 horse-power at Chelsea and 24,000 horse-power at Farmers; both new units are to be in operation early in 1929.

Gatineau Power Company has also in prospect an 80,000-horsepower development under a head of 68 feet at Nigger rapids, some miles below Maniwaki on the Gatineau river.

For the benefit of all these plants, the Mercier dam, on the Gatineau river at Bitobi rapids, constructed by Gatineau Power Company, is being operated by the Quebec Streams Commission so that the minimum flow at Chelsea is not less than 9,000 second-feet. The Mercier dam creates, in the Lake Baskatong area and the adjacent Gatineau valley, a very extensive storage reservoir of 100 billion cubic feet.

Plans have been prepared for two additional storage reservoirs in the Gatineau watershed; one under preliminary construction to be completed by the end of September 1929, in Cabonga lake to impound 45 billion cubic feet at the head of the Gens-de-terre river, tributary to the Baskatong storage, and the other in Desert lake, in the Desert River watershed draining into the Gatineau at Maniwaki. All reservoirs are constructed by the company under authority of the Quebec Streams Commission which operates them so as to assure the amount of water required for power, even in the years of lowest flow.

Gatineau Power Company is also adding a second unit of 25,000 horse-power to its Bryson plant on the Ottawa river, the new unit to be in operation early in 1929.

In connection with the power supplied from the above-mentioned plants, the company also has important transmission lines to construct, and during 1928 completed a 220,000-volt line from Paugan Falls to connect at Chats Falls with the line to Toronto and a 110,000-volt line from Farmers plant to connect with Ottawa and Eastern Ontario Hydro System, while a 110,000-volt line is being constructed between the Bryson plant and Hull, Quebec.

The Shawinigan Water and Power Company has added a 43,000-horsepower unit (No. 7) in No. 2 Shawinigan plant, bringing the capacity of this plant to 178,500 horse-power; No. 8 unit of the same capacity is being installed to be in operation in March, 1929.

The Shawinigan Company, whose total installation in various plants is rapidly approaching 700,000 horse-power, has during the past year acquired the lease for an important power reach on the St. Maurice river, involving a total descent of nearly 650 feet with a projected installation of 1,000,000 horse-power at 3 or 4 sites; extensive detail surveys are now being carried on to prepare plans for the developments, the first of which is to be in operation in 1933.

The Quinze Power Company has added 2 units of 10,000 horse-power each to their plant on the Quinze river, Upper Ottawa, the total installation now comprising 4 units.

On the Saguenay river the Duke-Price Power Company has added unit No. 11 of 45,000 horse-power to the Isle Maligne plant.

At Chute-à-Caron, on the same river, construction has been actively pursued throughout the year on the hydro-electric development of the Alcoa Power Company. The development is being undertaken in two stages. The initial development which is now under construction will consist of four 65,000-horsepower units, for operation under a head of 150 feet. The contract has now been let for these units. The second development will have an installed capacity of approximately 1,000,000 horse-power and will operate under a head of 205 feet. Water for the second development will be supplied by a canal from the dam of the initial development. The initial development is scheduled to be completed July 1, 1931.

Other installations placed in operation during 1928 include an addition of 2,400 horse-power by Ayres Limited on the North river at Lachute, a 1,050-horse-power hydro-electric plant completed for The Cie Electrique de la Sarre on La Sarre river near the town of the same name, another of 800 horse-power on Belle river in the Saguenay district for the St. Jerome Light and Power Company, a 760-horsepower addition to the site of Sherbrooke Water Works plant on the Magog river, the addition of 182 horse-power by the Barrett Company, Limited, at the former McArthur site on Assomption river at Joliette, the Cie Electrique Ste. Catherine's 150-horsepower plant on the outlet of lake St. Joseph at Ste. Catherine, and the Cie Electrique de Charlevoix's 140-horse-power plant at Boudreault creek at Les Eboulements Wharf.

Among other projects under active construction may be mentioned the Montreal Island Power Company's development on des Prairies river near Montreal, where work is well advanced on the power house, spillway, and extensive headworks, the plant to be in operation by October, 1929, with an initial installation of 6 units each of 8,800 horse-power under a head varying between 18 feet and 26 feet, while the ultimate installation is to be 9 or 10 similar units.

Preliminary construction operations are also under way for the James MacLaren Company's extensive project on Lievre river, comprising a hydro-electric plant at High Falls having an initial installation of 90,000 horse-power and ultimately 120,000 horse-power; the project also includes a 25-billion cubic foot storage reservoir at Cedar Rapids and a 250-ton pulp and paper mill at or near Buckingham.

The city of Sherbrooke has completed a new hydro-electric plant at Westbury on the St. Francois river, the installation consisting of 2 units of 2,900 horse-power each.

Prospective developments in Quebec include a 30,000-horsepower plant at Chats falls on the Ottawa river; the city of Montreal's 15,000-horsepower development from the Lachine rapids on the St. Lawrence; a 250-horsepower development by the St. Lawrence Paper Mills on Trinity river; a 375-horse-power hydro-electric plant on Coaticook river near Dixville; another of 525 horse-power initial capacity on Hall river near Bonaventure, Quebec, and a 287-horsepower addition to the Regent Knitting Mills on the North river at St. Jerome.

The Quebec Streams Commission, in addition to the work already mentioned on the Gatineau river, has continued to encourage and enhance water-power development in various sections of the province through the beneficial operation of its extensive storage reservoirs at Gouin dam and Manouan on the St. Maurice river; Allard dam and lake Aylmer on the St. Francois; Taschereau dam on lake Kenogami; Mercier dam on the Gatineau and others on Ste. Anne de Beaupre, Metis and North rivers. During the past year, the commission also completed flood protection works on river du Bras at Baie St. Paul; investigated power developments on the Ottawa river; further storage reservoirs on the Gatineau, du Lievre, Peribonca and Richelieu rivers. It has also prepared profiles of the Nicolet, Coaticook and l'Achigan rivers.

New Brunswick.—The year was notable in New Brunswick as it marked the completion of the initial stage and the bringing into operation on October 1 of the Grand Falls development on the St. John river of Saint John River Power Company, a subsidiary of Canadian Hydro-Electric Corporation. This development, which is the largest in the Maritime Provinces, is designed to include four 20,000-horsepower units operating under a head of 130 feet. One of these was placed in operation on October 1, 1928, a second early in 1929, while a third is expected to be in operation by October of the same year.

The Fraser Companies Limited, who were the first customers for Grand Falls power, have contracted to take 20,000 horse-power for their mills in New

Brunswick. Most of the remaining power at Grand Falls will go to pulp and paper mills to be erected by the New Brunswick International Paper Company. One of these mills, with a daily capacity of about 500 tons of newsprint paper, will be located at Dalhousie on Chaleur bay and will be supplied over a 132,000-volt transmission line approximately 110 miles in length. The New Brunswick International Paper Company also proposes to build a bleached sulphite mill on the Miramichi river.

Apart from this work at Grand Falls no new hydro-electric development was under way in New Brunswick during the year, but the New Brunswick Electric Power Commission built a 6,600-volt transmission line 25 miles long from its Shediac line to the municipalities of Dorchester and St. Josephs.

Nova Scotia.—In Nova Scotia the year was one of widespread activity in hydro-electric development, new installations to the extent of 8,440 horse-power being brought into operation, while a number of new developments were undertaken which, when completed, will add 34,550 horse-power to the province's total.

The outstanding construction was that carried forward by the Nova Scotia Power Commission. The Sandy Lake development of the St. Margaret Bay system was brought completely into operation in June by the installation of the second generator. The two turbines of 2,500 horse-power each were installed in 1927 and were credited to that year. Owing to the rapidly increasing load on this system new development will soon be required and the commission has investigations under way with a view to diverting water from the Ingram river into the Indian river, also sites have been investigated on the North East and Sackville rivers. From all of these sources it has been tentatively estimated that 25,000,000-k.w. hours of new energy may be made available.

On the Mersey river the commission has three developments under construction which will have a combined capacity of 31,050 horse-power, the first at Upper Lake falls with 7,750 horse-power under an average head of 30 feet, the second at Lower Lake falls with 10,600 horse-power under a head of 48½ feet and the third at Big falls with 12,700 horse-power under a head of 58½ feet. This power is being developed to fulfill a contract with the Mersey Paper Company which calls for the delivery of 20,000 horse-power on January 1, 1930, to supply a paper mill which that company is building at Brooklyn near the town of Liverpool. In addition the commission took over and reconstructed the development of the town of Liverpool at Guzzel falls on the Mersey river. Two units of 700 horse-power each were installed, replacing the old installation of 700 horse-power. The output of this plant will supply power for construction purposes at the three new developments and will also serve the Liverpool and Milton systems of the commission.

On the Tusket river at Tusket falls the commission has a development of 3,000-horsepower capacity under construction comprising three units of 1,000 horse-power each. The energy from this plant will go to fulfil a contract which the commission entered into on September 15, 1928, with the Western Nova Scotia Electric Company and the Cosmos Imperial Mills, Limited, both of Yarmouth. It is expected the power delivery will commence about September 1, 1929.

The commission also prepared a report in connection with the proposed Lake Ainslie development in Cape Breton island and carried on investigations in connection with the increasing of the supply of power from the East River Sheet Harbour.

Other activities in Nova Scotia included the completion of a 4,350-horse-power development of the Avon River Power Company at Avon River falls and the taking over of power service by that company in the communities of Waterville, Cambridge, Goldbrook, Lakeville, Woodville, Somerset, Aylesford, Auburn

and Morristown. The same company commenced in September the construction of a 500-horsepower plant on Fall river to supply communities along the Truro road between Waverly and Brookfield. This plant will be in operation early in January, 1929. The Northumberland Light and Power Company completed and brought into operation on July 10 a development of 190 horse-power at the falls of the Tatamagouche river to supply light and power to River John, Tatamagouche, Malgash, Wallace, Pagwash and intervening points. The Digby County Power Board completed two extensions to its transmission system of 21 and 40 miles respectively, thus bringing service to sixteen municipalities.

Prince Edward Island.—In Prince Edward Island the Montague Electric Company Limited, on January 22, placed in operation its new 160-horsepower development, the installation of which had been noted in the 1927 review. The energy from this development goes to supply the communities of Montague, Cardigan, Georgetown and intervening territory.

UTILIZATION OF DEVELOPED WATER-POWER

It is difficult to accurately trace the ultimate use to which the power from any particular hydraulic development is put, except in the case of those sites developed for specific lines of manufacture, but for the purpose of this report the installation is divided in Table 2 under the three main headings of central electric stations, pulp and paper mills and other purposes, and it is proposed later to analyse the figures under these three heads:—

4,445,693 horse-power or 83·1 per cent of the total is installed in central electric stations for general distribution for domestic, municipal and commercial lighting and power purposes. The large proportion of the whole installation installed in central electric stations serves to emphasize the comment already made on the growing importance of the distribution of electricity through the medium of central electric stations.

572,976 horse-power or 10·7 per cent of the total is installed in the power plants of pulp and paper mills and in addition the industry purchases some 789,500 horse-power from the hydro-electric central stations.

330,563 horse-power or 6·2 per cent is installed for general industrial use such as driving, saw, grist and grinding mills, machine shops, pumping plants, electric reduction plants and for mining operations. Bulletin 1227 recently issued by this service showed that there is a hydraulic installation for mining of some 96,000 horse-power while 339,500 horse-power is purchased by that industry from hydro-electric central stations.

It is generally conceded that an abundant supply of power is one of the greatest factors leading to commercial supremacy. Its facility in contributing to the civic and domestic amenities of life through its distribution as electricity, is no less marked, so that Canada's rapidly increasing high average per capita hydraulic power installation, is one of the most important contributing agents to her present and future prosperity.

Column 7 of Table 2 shows the hydraulic installation for Canada and each of the provinces. The average for Canada has now reached the outstanding figure of 554 horse-power per 1,000 of population.

As shown in Table 1 the highly industrial but non-coal producing provinces of Ontario and Quebec contain over 60 per cent of Canada's known potential water-power, while the change from agricultural to industrial predominance has led to the installation in these two provinces or over 80 per cent of the country's total hydraulic development representing an installation in Quebec of 902 horse-power and in Ontario of 590 horse-power per 1,000 of population. British Columbia with a comparatively small population but large power consuming industries, viz., pulp and paper and mining, occupies third place in order of

total installation and is a close second to Quebec in per capita installation; Manitoba, fourth in both population and total installation has an average installation of 476 horse-power per 1,000 of population. The Maritime provinces, not so bountifully supplied with water powers yet having more than sufficient for present needs and ample to provide for normal industrial expansion in the future, have in Nova Scotia a total installation of 74,356 horse-power or 136 horse-power per 1,000 of population, in New Brunswick 67,131 horse-power or 162 horse-power per 1,000 of population and in Prince Edward Island 2,439 horse-power or 28 horse-power per 1,000 of population. Abnormal conditions in the Yukon with a small population and heavy power demands for low grade gold mining result in the total installation of 13,199 horse-power showing a utilization of 1,039 horse-power per 1,000 of population, a figure, of course, not comparable, on account of the conditions mentioned, with the corresponding figures of the other provinces.

Water Power in the Central Station Industry

Canada's central-electric station industry, the generation or distribution of electrical energy for public use, has attained record proportions because the wide distribution and accessibility of her abundant water powers is such that with modern methods of transmission, electricity for industrial, agricultural, and domestic use is available to all but a very small proportion of her population. The certainty of the supply of power and the assurance of its continuance at uniform or lower rates through the medium of the central-stations has done much to attract industries which would not in the ordinary course engage in the production of their own power.

In the central-electric station industry over 95 per cent of the primary power equipment is energized by falling water while the diversity of use of hydro-electricity induced by moderate prices results in almost 99 per cent of the total electrical output being generated in the hydraulic stations. An analysis of the developed water-power utilized in central-electric stations is given in Table 3.

These hydro-electric central stations number 296, of which 207 are operated by commercial organizations and 89 by municipalities, government commissions or other public bodies. The commercially owned stations maintain a total turbine installation of 3,200,795 horse-power while the municipal stations have a total installation of 1,244,898 horse-power. A small fuel reserve, 176,865 horse-power, or about 5 per cent of the hydraulic installation of each class is maintained for use in emergencies. In addition to the central-electric station organizations included in the above totals, certain hydraulic plants sell small amounts of electricity incidentally to their main businesses. This power is mostly sold for lighting and service, in many instances, at night only.

Water Power in the Pulp and Paper Industry

The relationship between the pulp and paper and water power industries is a most intimate one and one of great importance to the industrial and economic structure of the Dominion in that each industry makes a most substantial contribution to the success of the other. The extent of this contribution is clearly revealed in the following analysis which shows that the pulp and paper industry relies almost entirely upon water-power for its energy requirements, whilst over 28 per cent of the hydraulic turbine installation in Canada is required to supply the power necessary for the manufacture of pulp and paper.

The pulp and paper industry is Canada's greatest manufacturing industry, its gross and net values of production, $219,329,735 and $134,516,073

respectively, and its disbursements for salaries and wages, $45,674,293, being greater than for any of the other manufacturing industries. In fact Canada has lately taken the leadership in the manufacture of newsprint paper, her output of 2,082,830 tons, valued at $132,286,729 for the calendar year 1927, being six hundred thousand tons in excess of that the United States, the second producing country, while her export of this commodity, 1,881,685 tons, contributed $129,637,687 to the country's favourable trade balance and exceeded the combined newsprint export of all other countries.

Importance of Low Cost Power.—Newsprint paper made up 84·4 per cent of the total reported tonnage of paper manufactured in Canada during 1927 and, as the production of newsprint requires an installation of practically 100 horsepower per ton of output per day, the necessity for abundant supplies of low priced power at once becomes apparent. In any industry the relative necessity for low cost and adequate power may be gauged by the amount required per dollar value of product and, with certain electro-chemical and electro-metallurgical processes, the requirements for the manufacture of pulp and paper rank among the highest. It is not surprising, therefore, that 90 per cent of the motive power in the industry is derived from the energy of the Dominion's abundant and advantageously located water falls.

The continuous operation of mills in this industry, usually 24 hours a day, lends itself to the securing of a very low unit cost of power where the power is derived from water, since the main item in this cost is the interest on the capital invested in the hydraulic development which remains constant whether the plant operates ten hours a day or twenty-four. Whereas, in the case of fuel-power, the higher cost factors of operation and fuel are directly affected by the length of the daily period of operation. Also, in mills using hydro-electric power the development of the electric steam-generator has provided additional economies as any available surplus or off-peak power may be utilized for producing steam for pulp cooking, drying, heating and similar uses.

Water Power Installations for Pulp and Paper Manufacturing.—Table 4 lists the various pulp and paper mills in Canada using hydraulic or hydro-electric power, and except where noted in the table, are in actual operation. These mills are divided according to their product into pulp, pulp and paper and paper mills, although for the sake of brevity the generic term " pulp and paper mills " may be applied to any of them in this report. The total hydraulic installation, the horse-power of the turbines connected direct to pulp and paper machines and of those connected to electric generators are shown in separate columns. In the case of the mills having no hydraulic installation of their own the name of the hydro-electric central station organization supplying the power is given.

The horse-power of the hydraulic turbines as stated is the rated capacity given by their manufacturers and the total figures, therefore, represent the total hydraulic horse-power installed. This must not be confused with the actual horse-power used during any census period which may or may not be the same, depending upon operation and output. It is probable also that in the case of some of the mills part of the installation is used for sawing lumber or for the production of similar side lines to the manufacture of pulp and paper, while in many instances part of the electricity purchased or generated is used to supply light to the mills and adjacent houses or even sold for distribution to central-electric station organizations.

The water-power installation of the pulp and paper mill organizations listed in Table 4 aggregates 565,362 horse-power, of which 283,009 horse-power is directly connected to pulp and paper machines and 282,343 horse-power to

electric generators. *In addition* to this there is a large turbine installation in central station plants producing the power sold to pulp and paper mills. Without going into details it may be stated that a careful analysis of the figures for this power, sold both on the horse-power year and the kilowatt-hour basis, indicates that the turbine installation must be virtually equal to the aggregate installation of the motors which utilize this power, given in Table 5, namely, 789,530 horse-power. This may be tabulated thus:—

Installed power (table 4)..	565,352 horse-power
Purchased power (table 5)..	789,530 "
Total in industry..	1,354,882 horse-power

We thus obtain the result that *the turbine installation supplying power to pulp and paper mills in Canada aggregates, in round figures, 1,355,000 horse-power,* of which 1,071,873 horse-power is hydro-electric and the remainder direct hydro drive.

The total hydraulic installation utilized in the pulp and paper industry is, therefore, over 28 per cent of the total installation for the whole Dominion and the power purchased, in 1927, amounted to almost one-third of all the power produced for sale by central electric stations and earned for them, as shown in Table 6, approximately $11,500,000. It is evident, therefore, that the pulp and paper industry has an extremely important relationship to the water-power industry in Canada.

The advantages of the conversion of hydraulic power to electrical energy appear both in the quality of the product, which is improved by the uniform speed obtained, and in the fact that under modern methods of transmission it is possible to develop power at sites more or less remote from centres of labour and transportation and to transmit it to points where these facilities are available for mill operation. Modern practice in pulp mill construction usually provides for the development of the mill and power sites as separate projects, i.e., the site of the mill is selected from the point of view of operation and transportation while the power station or stations are located from the standpoint of efficiency of generation, often in situations unfavourable to mill construction.

Steam Power.—The use of steam as a source of power for this industry is very limited, the total installation amounting to only 120,352 horse-power or 8·2 per cent of the total power installation and being usually prompted by special conditions such as operation in close connection with the manufacture of lumber when refuse from the latter can be used as fuel under the boilers. There is also some slight use of internal combustion engines, engines rated at 763 horse-power being installed.

Provincial Distribution of Pulp and Paper Mills.—Reference to Table 4 shows that in *British Columbia* there are three pulp mills and two pulp and paper mills generating their own power, while a pulp and paper mill and a paper mill purchase hydro-electricity from the British Columbia Electric Railway Company. The three pulp mills are owned by the British Columbia Pulp and Paper Company, Limited, and have an aggregate turbine installation of 4,290 horse-power, of which 2,155 horse-power is directly connected to pulp making machinery and 2,135 horse-power to electric generators. Two of these mills are situated in the coast region of the main land, and the third, which has not been operated for some time, towards the northwesterly end of Vancouver island.

The larger pulp and paper organizations, Pacific Mills, Limited, and the Powell River Company, Limited, have hydraulic installations of 26,850 horse-power and 49,860 horse-power respectively, about 70 per cent of each being connected to electric generators.

Manitoba has one mill, a pulp and paper mill erected by the Manitoba Paper Company and since absorbed by the Abitibi Power and Paper Company, Limited. It purchases its power from the Manitoba Power Company under a long-term contract.

Ontario has 12 pulp mills, 17 pulp and paper mills, and 18 paper mills with a combined installation of 238,880 horse-power, over 60 per cent of which is connected to electric generators. Twenty-eight of the mills purchase all or part of their power and have a motor installation of 185,472 horse-power driven by purchased power (Table 3).

Outstanding among the pulp and paper organizations in Ontario may be mentioned the Abitibi Power and Paper Company, Limited, which has a pulp mill at Smooth Rock falls and Pulp and Paper mills at Iroquois Falls, Fort William, Sault Ste. Marie, Espanola and Sturgeon Falls. In connection with the Smooth Rock Falls mill the company has a 9,350-horsepower installation on the Matagami river; the Iroquois Falls mill is furnished with power from two plants at Iroquois Falls and Twin Falls on the Abitibi river with an aggregate installation of 58,000 horse-power supplemented by power purchased from the 48,000-horsepower plant at Island Falls on the same river owned by a subsidiary—the Abitibi Electrical Development Company. The Sault Ste. Marie mill has a 14,400-horsepower installation on the St. Mary river and purchases additional power from the Great Lakes Power Company. The Espanola mill has a 20,800-horsepower development on the Spanish river and also secures power by purchase from the plants of the International Nickel Company on the same river; whilst the Sturgeon Falls mill is operated by power from two plants on the Sturgeon river, one at Sturgeon Falls and the other at Smoky Falls, which have an aggregate installation of 23,790 horse-power. The Fort William mill is operated entirely by purchased power. The Abitibi Company's turbine installations aggregate 174,340 horse-power, of which 107,450 horse-power is connected to electric generators.

The Spruce Falls Power and Paper Company, which, until the present year, operated a pulp mill with a hydraulic installation of 2,500 horse-power on the Kapuskasing river in Kapuskasing, has recently completed a 500-ton pulp and paper mill in Kapuskasing, together with a development of 56,250 horse-power at Smoky Falls, 40 miles distant, on the Mattagami river to supply its power.

The J. R. Booth Limited mill on the Ottawa river at Ottawa utilizes an installation of 28,789 horse-power, 14,000 horse-power of which is connected to electric generators, in the production of its varied output.

Much of the power purchased in Ontario for the operation of the mills which do not generate their own power is procured from the Hydro-Electric Power Commission which supplies, among others, the pulp mills of the Great Lakes Paper Company, Limited, at Fort William, the Nipigon Corporation Limited at Nipigon, and the pulp and paper mills of the Provincial Paper Mills and the Thunder Bay Paper Company at Port Arthur.

The province of *Quebec,* with the largest output among the provinces, has 15 pulp mills, 23 pulp and paper mills and 15 paper mills. Thirteen of the pulp mills, 13 of the pulp and paper mills and 11 of the paper mills operate their own hydraulic developments and maintain an aggregate installation of 215,736 horse-power, of which 145,296 horse-power is direct connected to the mill machinery and 70,440 horse-power to electric generators. The mills purchasing all or part of their power, 28 in number, maintain a motor installation driven by purchased power of 566,371 horse-power.

Outstanding mills organizations producing their own power are those of Price Bros. & Company, Limited, operating a pulp mill at Beausejour where 3,150 horse-power is installed on the Rimouski river, and pulp and paper mills at Jonquiere and Kenogami, where four developments, two on the Ausable, one

each on the Shipshaw and Chicoutimi rivers, have a combined installation of 59,300 horse-power. This company also purchases almost the entire output of the 10,800-horsepower plant of the Shipshaw Power Company, a subsidiary company. Price Bros. & Company, Limited, also operate a third very large pulp and paper mill at Riverbend, the power for which is secured from the Isle Maligne plant of the Duke-Price Power Company on the Saguenay river.

The Quebec Pulp and Paper Company, Limited, operates two large pulp mills, one at Chicoutimi where 20,220 horse-power is installed in two plants on the Chicoutimi river and one at Val Jalbert with an installation of 7,300 horse-power on the Ouiatchouaniche river.

The Canada Power and Paper Corporation, operating pulp and paper mills at Shawinigan Falls, Windsor Mills, Grand'Mere and Three Rivers, has an installation of 17,910 horse-power on the St. Maurice river, using water drawn from the headworks of the Shawinigan Water and Power Company for the operation of its Shawinigan Falls mill, three developments totalling 5,990 horse-power, one of which is on the St. Francis and two on the Watopeka for the operation of its Windsor mills and in addition purchases power from the Shawinigan Water and Power Company to operate its Three Rivers mill and to supplement the power at its Shawinigan Falls mill. Power to operate its Grand'Mere mill is secured from the Laurentide Power Company.

The Canadian International Paper Company purchases the power for the operation of its Gatineau mill from the large Gatineau river hydro-electric developments of a subsidiary, the Gatineau Power Company. Power for the operation of its Three Rivers mill is obtained from the Shawinigan Water and Power Company, while its mill at Kipawa, which specializes in a high grade of rayon cellulose, receives its power from the Gatineau Power Company's 25,050-horespower plant on Gordon creek. This Company also operates a sulphite mill at Hawkesbury, Ontario, supplied with power by the Gatineau Power Company's plants on the Rouge river in the province of Quebec.

In addition to the hydraulic development specifically referred to there are numerous others to which space precludes specific reference.

In *New Brunswick* there are four pulp mills and one pulp and paper mill with a second under construction. The total hydraulic turbine installation of the mills providing their own power is 13,728 horse-power, of which all but 1,900 horse-power is connected to electric generators. The Fraser Companies, Limited, have a pulp mill with its own hydro-electric plant at Edmunston, which also secures power from the St. John River Power Company's plant at Grand Falls, and a second mill is operated at Chatham with electricity purchased from the New Brunswick Electric Power Commission. The St. George Pulp and Paper Company, a subsidiary of the International Paper Company, has a pulp mill with a hydraulic development of 2,668 horse-power at St. George. The pulp and paper mill in operation is situated near Bathurst and is under the management of the Canadian International Paper Company, while the same Company has a new mill under construction at Dalhousie. The latter will utilize part of the output of the St. John River Power Company's newly built hydro-electric station at Grand Falls.

Nova Scotia has seven pulp mills in operation and one pulp and paper mill under construction. All but one of the pulp mills generate their own hydro power and use it without conversion to electricity. They have an aggregate installation of 16,008 horse-power. The pulp mill purchasing power secures its supply from the Nova Scotia Power Commission as will the pulp and paper mill when completed.

Future Power Requirements of the Industry

The growth of population, education and prosperity during the past century has brought about an immense increase in the number, size and circulation of newspapers with a corresponding increase in other publications, both periodicals and books. In addition new methods of merchandising make increasing demands on the product of the pulp and paper mill. It is to be expected, therefore, that there will be a steadily increasing demand for newsprint, book, wrapping and other papers and kindred products with, perhaps, temporary setbacks when economic or other causes bring about reductions in commercial activity. At times, there may be over development of the industry when production facilities temporarily outstrip the demand. Such a situation appears to have been reached in Canada at the present time, but there is no reason to believe that this situation will not soon adjust itself by the operation of the natural growth of demand. Under these overall circumstances, therefore, it is certain that a country such as Canada which still possesses widely distributed forests and ample conveniently located water-power (see Table 7), must make an increasing contribution to the world supply of pulp and paper products.

Water-Power in the Mineral Industries of Canada

In the Annual Report of this Service for the year ending March 31, 1924, an extended reference was made to the subject of water-power in the Mineral Industries of Canada and was prompted by the opening of numerous promising prospects in areas that hitherto had not been systematically explored for mineral deposits.

In the five years which have since elapsed many of these prospects have become producing mines, others are rapidly approaching the same stage and, further, exploration is extending and intensifying with every indication that the production of precious and base metals and other mineral resources will steadily increase.

The mining industry is already established as one of the leading basic industries of the Dominion and when it is realized that in addition to the ore reserves that have already been blocked out and the discoveries which have been made but not yet fully proved by mining operations, there is an area of more than three million square miles being 80 per cent of the total area of the Dominion, forming a prospective mineral field, there is ample justification for the confidence exhibited in the future of mining in this country.

Mining operations and the mineral industry generally in Canada, require very large amounts of power and the profitable operation of many mines is only made possible by the low cost at which ample power can be secured from hydro-electric sources. Ample power supplies make it possible to mine on a large scale with consequent lowered costs while the fact that the power is obtaintable at low cost has the great economic advantage of permitting the profitable operation of relatively low grade deposits. Thus the scope of the industry is immensely expanded and many millions of tons of ore can be treated which, if power was limited and expensive, would have no commercial value. In fact, it is no exaggeration to say that, without water-power, the mining industry of Canada could not have approached its present magnitude.

Extent and Growth of Mining Industry.—It is not the intention here to deal in any comprehensive way with the mining industry of the Dominion as this has already been done by the Dominion Bureau of Statistics in The Canada Year Book 1927-28, nevertheless, a brief reference to the extent and growth of the industry will not be out of place.

Owing to the diversity of units and products, the total mineral production can only be brought to a common denominator when dealt with in terms of value, varying prices attendant on fluctuating conditions, however, vitiate comparisons on a value basis. In spite of this it is nevertheless interesting to note the growth of the value of mineral production from $10,000,000 in 1886 to $64,000,000 in 1900 and $228,000,000 in 1920. In that year commodity prices reached their peak and have since fallen greatly; nevertheless, the value of production for 1927 reached $245,000,000, this growth in value representing a very much more substantial growth in quantities.

Mineral production is listed under some 60 items, 22 of which had a value in 1926 exceeding $1,000,000 each and it is interesting to note that the Dominion is at present producing 90 per cent of the world's nickel, 76 per cent of its asbestos and 55 per cent of its cobalt, whilst it is the third ranking country in the production of both gold and silver.

The following table lists the value of mineral production for 1927 as published by the Dominion Bureau of Statistics.

Production by Provinces

Province	Value in Dollars	Percentage
Nova Scotia	30,111,221	12·2
New Brunswick	2,148,535	0·9
Quebec	28,870,403	11·7
Ontario	89,982,962	36·3
Manitoba	2,888,912	1·2
Saskatchewan	1,455,225	0·6
Alberta	29,309,223	11·8
British Columbia	60,801,170	24·6
Yukon	1,789,044	0·7
	247,356,695	100·0

A brief examination of the above table indicates how widespread the industry is and it should be borne in mind that the figures include little or no production from some of the outstanding recent developments amongst which may be mentioned the opening of the Rouyn copper-gold area in Quebec; new gold discoveries in far western Ontario and the proving of new copper-lead-zinc and nickel-copper deposits in the Sudbury region; the proving of copper-zinc-gold-copper areas in Manitoba and eastern Saskatchewan and new mineral areas in British Columbia, in addition to these there is further development of gold, lead and zinc properties in Nova Scotia where the salt and gypsum industries are also expanding.

This brief and inadequate review, which makes no mention of the coal industries in Nova Scotia, Alberta and British Columbia, the growing natural gas and petroleum production and the extensive and growing output of cement, clay products and other building materials is merely intended to indicate the magnitude and wide distribution of the mineral industries of the Dominion as an introduction to a more detailed discussion of the use of power therein and the water-power available for their development.

Distribution of Water-Power.—Detailed examination shows that ample water-power is available for the development of the mineral areas in every province with the possible exception of limited areas in the coal fields of the southern portions of Alberta and Saskatchewan. It is this fortunate distribution of the Dominion's water-power that not only facilitates the development of the richer ore bodies but makes possible the profitable exploitation of the lower value ore bodies that could not otherwise be developed. This is particularly in evidence in the practically coal-less, but otherwise highly minera-

lized, provinces of Ontario and Quebec, which contain minimum water-power resources of some 14 million horse-power well distributed over their whole areas.

The Use of Power in the Mineral Industries.—The principal uses of power in the mineral industries are in the extraction of the mineral and in crushing, smelting, refining and other processes. The extraction of the mineral requires power for compressed air for drilling; for stripping, hoisting, hauling and conveying; for pumping for water supply and drainage; for lighting, heating and ventilating; for machine, blacksmith and framing shops, etc.

Crushing, smelting, refining and other processes require large amounts of power—in the metallic industries the total power required is from 1½ to 2½ horse power per ton of ore produced and from 50 to 80 per cent or more of this may be required in the treatment of the ore. In coal mining, when steam-power is used, some 10 per cent of the product is required for producing power, but several of the Canadian mines have now substituted hydro-electric power.

The following table shows the amount of power installed in the principal divisions of the industry in 1926:—

Horse-Power Installed—1926 (1)

Class of Industry	Fuel power	Water Power		Per cent of total power	Total Power	
		Generated	(2)Purchased		Amount	Per cent
Metallic	25,634	82,171	186,185	91·3	293,990	49·1
Fuels	105,791	12,000	19,075	22·7	136,866	22·9
Non-metallic	7,692	450	34,050	81·8	42,192	7·1
Structural and clay products	23,860	1,394	100,255	81·1	125,509	20·9
	162,977	96,015	339,565	72·8	598,557	100·0

(1) Based on statistics of Mineral Production of Canada, 1926, issued by the Dominion Bureau of Statistics.
(2) Rated horse-power of motors installed to use purchased power. It is assumed that all purchased power is hydro-electricity although a very small percentage may be fuel electricity.

It will be seen that 598,557 horse-power was installed for the mineral industry in 1926 and that 72·8 per cent of this was water power.

Compared with the figures for 1923, the installed fuel-power decreased by 45 per cent and the installed water-power increased by 57 per cent, giving a net increase in the installed horse-power of 17 per cent.

It is also of interest to observe that the power purchased from central stations, expressed as rated horse-power of motors installed, constituted 57 per cent of the total horse-power installed.

The proportions of water and fuel-power may be summarized as follows:—

Proportions of Water and Fuel Power (1)

—	Horse-power installed	
	H.P.	Per cent
Water-power—		
Generated	96,015	16·0
Purchased	339,565	56·8
Total	435,580	72·8
Fuel-power—		
Coal (steam)	147,028	24·6
Gas and oil	15,949	2·6
Total	162,977	27·2
Grand total	598,557	100·0

(1) Based on statistics of mineral production of Canada, 1926, issued by the Dominion Bureau of Statistics.

Particulars of the use of power by some of the principal mines and other mineral industries are given in the following section.

Water Power Installation for Mineral Industries.—Extensive and widely distributed as are Canada's mineral resources, there is no field operating or prospective where ample supplies of power, developed or awaiting development, are not available.

In the Maritime Provinces, based on value of production almost 90 per cent of the mining carried on is for the recovery of coal and so far water-power has not been utilized here for this purpose although its satisfactory adaptation to and growing use for coal mining in British Columbia and Alberta would indicate that a similar use in the Maritimes might be only a matter of time. In Nova Scotia, however, three hydraulic developments have been installed by gold mining companies while two are operated by stone cutters. In addition considerable purchased power is used in the mining of various non-metallic minerals found in both New Brunswick and Nova Scotia.

Although the mineral output of the province of Quebec at the present time is mainly non-metallic, the value of the asbestos output alone being over four times that of all the metals recovered, copper, gold, iron, lead, manganese, silver and zinc are all being mined. The leading asbestos mines of the world are found in the southeastern section of the province, over 75 per cent of the present world supply of that mineral being mined in that area. There is also a very extensive range of other non-metallic minerals in the province, feldspar, graphite, ironoxides, magnesite, mica, mineral waters, phosphate, pyrites, quartz, talc and soapstone being mined, while the production of clay products and other structural materials also forms a very important part of the mineral production of the province.

The extensive power demands of the mineral industries of the province are almost entirely supplied by hydraulic installations, the greater part of the power being electricity purchased from the central hydro-electric stations. Of the total power installation of 131,965 horse-power reported as used by the companies operating during 1926, (the period covered by the latest power statistics published by the Dominion Bureau of Statistics), over 95 per cent was water-power, approximately three-fifths of which was purchased in the form of hydro-electricity from central electric station organizations.

The Aluminum Company of Canada operates a 52,325-horsepower plant at Shawinigan Falls and purchases large amounts of power from the Duke-Price Power Company for the operation of its plant at Arvida pending the development of its Chute-à-Caron site on the Saguenay where it is expected that up to 700,000 horse-power will be installed.

The Shawinigan Water and Power Company transmits large amounts of hydro-electricity from Shawinigan Falls across the St. Lawrence river near the city of Three Rivers to the asbestos mines of the Eastern Townships. Power is also furnished to this field by a subsidiary of the Shawinigan Company, the St. Francis Water Power Company from its station on the St. Francois river. The Southern Canada Power Company supplies a small amount of hydro-electricity for copper mining. Montreal Light, Heat and Power Consolidated and the Gatineau Power Company sell large amounts of power for the manufacture of Portland cement, the former company also supplying power to the large brick plants in the Montreal district.

In the western section of the province the Rouyn copper-gold area is being supplied with hydro-electricity by the Canada Northern Power Corporation operating plants aggregating 53,390 horse-power in Ontario and one of 40,000 horse-power on the Quinze river in Quebec.

The province of Ontario ranks first among the provinces in diversity and value of mineral production, and being, like Quebec, situated in the acute fuel area, depends almost entirely on the abundant supplies of hydraulic and hydro-electric energy which are, fortunately, available to every field.

The diversity of application of hydraulic power to mineral production in the province is indicated by the statement that of the twenty odd active divisions of production only four are not energized by hydro power, while the preponderance of use is shown by approximately 148,000 horse-power of the 173,000 horse-power reported employed being hydro power produced or purchased by the mining companies.

While much power for mining has been generated and distributed by central electric station organizations the mining companies have also developed large amounts of power for their own use, although their power operations, through the formation of subsidiary companies, have as a general thing, been kept separate from their mining operations.

The outstanding central electric station organization operating in the gold and silver mining fields of northern Ontario is the Canada Northern Power Corporation, operating such well known companies as the Northern Ontario Light and Power Company, the Northern Canada Power Company, the Great Northern Power Corporation and the Northern Quebec Power Company.

The Northern Ontario Light and Power Company operates two hydro-electric plants on the Montreal river and one on the Matabitchuan river and a hydro-compressed air plant on the Montreal river with an aggregate installation of 27,090 horse-power supplying power mainly for silver mining in the Cobalt area.

The Northern Canada Power Company owns and operates three plants on the Mattagami river and operates under lease the plant of the Great Northern Power Corporation on the Montreal river. The aggregate installation of these plants is 31,800 horse-power. The Northern Quebec Power Company (Quinze Power Company) with a 40,000-horsepower plant on the Quinze river in Quebec is also operated by the Northern Canada Power Company.

The plants of the Northern Canada Power Company were installed to serve the Timmins and Porcupine gold areas and the Great Northern Power Corporation's plant to serve the Kirkland lake gold area. These plants and those of the Northern Ontario Light and Power Company and the Quinze Power Company are now all inter-connected so that there is an uninterrupted flow of power throughout the gold and silver areas of northern Ontario and western Quebec. There are also a number of small private hydro developments serving individual mines in this area.

The copper-nickel deposits in the Sudbury district receive power mostly from hydro developments operated by the mining companies themselves through the medium of subsidiary companies.

The International Nickel Company of Canada Limited operates two plants owned by its subsidiary, the Huronian Company Limited, on the Spanish river at Turbine with an aggregate installation of 22,200 horse-power, and recently completed a third plant at the Big Eddy dam on the same river with an installation of 28,200 horse-power. The Mond Nickel Company, through its subsidiary the Lorne Power Company Limited, is supplied with power from a 7,300-horsepower plant on the Spanish river and from one of 4,800 horse-power on the Vermillion river. The Mond Nickel Company also purchases the greater part of the output of the Wahnapitae Power Company's three stations on the Wanapitei river, near Sudbury; these have an aggregate installation of 16,900 horse-power.

In the western section of the province the Algoma District Power Corporation which operated a 1,600-horsepower plant at High Falls on Michipicoten river to serve the recently re-opened gold mines in that district has almost completed the rebuilding of the plant to a capacity of 18,770 horse-power. Additional power for the same field might be available from the Steep Hill Falls plant of the Algoma Steel Corporation, Limited, on the Magpie river where 2,400 horse-power is installed. The recent gold discoveries in the Red Lake area also occur in a region of abundant water-power and the Hydro-Electric Power Commission of Ontario is installing 5,000 horse-power at Ear Falls on the English river to provide power for this field.

In the southern portion of the province production is limited to non-metallics and structural materials and here the demand for power is met by the extensive transmission systems of the Hydro-Electric Power Commission of Ontario or of central electric stations operating in the vicinity of the plants.

The Prairie Provinces—Manitoba, Saskatchewan, and Alberta—until quite recently, have not produced any of the metallic minerals but recent developments indicate that Manitoba has copper-gold and copper-zinc and Saskatchewan copper-zinc deposits of great promise. In Manitoba these have led to the construction of a 42-mile transmission line by the Manitoba Power Company to convey power under a 20-year contract from Great Falls station on the Winnipeg river to the mines of the Central Manitoba Mines, Limited, and in Saskatchewan to the leasing of Island Falls on the Churchill river to the Churchill River Power Company, a subsidiary of the Hudson Bay Mining and Smelting Company. Three 14,000-horsepower units are being installed at this site and provision made for three more to supply power for the mining operations at Flin Flon.

Manitoba possesses a comparatively small field of lignite coal, Saskatchewan has some 66,000 millions of tons of lignite and ranks third among the provinces of the Dominion in coal resources, while Alberta has semi-anthracite, bituminous and lignite coals constituting 88 per cent of the total coal resources of the country. These coal deposits have in the past, as in Nova Scotia, been depended upon to provide power for their own exploitation, but upon the completion of East Kootenay Power Company's transmission line into Alberta from British Columbia a number of the Alberta mines contracted for supplies of hydro-electric power. Among the coal mines which changed from steam to hydraulic power in this field may be mentioned the West Canadian Collieries at Bellevue and Blairmore, the International Coal and Coke Company at Coleman and the Hillcrest Collieries at Hillcrest.

The extension of the Calgary Power Company's transmission lines in 1927 and 1928 also resulted in a number of coal mines formerly using fuel-power adopting the more efficient and economical hydro-electricity, the Donaldson Coal Mine near Diamond City and the Hughes Mine near Elcan being so served.

In British Columbia water-power has been extensively developed for mining purposes, being used in the production of a wide range of both the metallic and non-metallic minerals, clay products and structural materials.

The large-scale operations for the recovery of zinc, copper and lead, carried on in the Kootenay district by the Consolidated Mining and Smelting Company of Canada Limited, operating such well-known mines as the Centre Star, Le Roi, War Eagle and Josie in west Kootenay and the Sullivan Mines at Kimberley in east Kootenay, are supplied with power from three plants on the Kootenay river with an aggregate installation of 16,900 horse-power operated by a subsidiary, the West Kootenay Power and Light Company, Limited. Power from these stations is transmitted over a very extensive transmission system from Bonnington Falls on the east to Princeton, Allenby and Copper mountain on the west, and north to Summerland and Kelowna. Power for the Sullivan Mine is secured from the East Kootenay Power Company.

One of the most important coal mining areas in Canada is that of the Crowsnest Pass and Elk river district in east Kootenay and here hydro-electricity has to a great extent replaced coal as a source of power for mining. The East Kootenay Power Company operating a 7,500-horsepower hydro-electric station on the Bull river and one of 15,000 horse-power on the Elk river, in addition to supplying power for the Sullivan Mines of the Consolidated Mining and Smelting Company, supplies many of the leading coal mines. The Crowsnest Pass Coal Company, Corbin Coal and Coke Company and the McGillivray Creek Coal and Coke Company are among the mines supplied.

On the Pacific coast the extensive copper and gold areas receive power from a number of important developments. The Granby Consolidated Mining, Smelting and Power Company has two stations with a combined installation of 13,200 horse-power on Falls creek; the Britannia Mining and Smelting Company, two, totalling 19,070 horse-power on Britannia creek; the Hedley Gold Mining Company, one of 1,600 horse-power on Similkameen river; the Surf Inlet Power Company, one of 1,200 horse-power at the outlet of Cougar lake, and there are a large number of smaller installations.

On Vancouver island extensive coal mining operations, conducted by the Canadian Collieries Limited, are supplied with power from a 12,000-horsepower hydro-electric plant, operated by the company on Puntledge river.

In Yukon Territory water-power sites were originally developed to supply power for mining, but only two of these need now be mentioned, viz., that of the new North-West Corporation Limited with 10,000 horse-power and that of the Yukon Gold Company with 3,180 horse-power. Consequent upon the reduction of mineral output in the Territory only a small amount of power is at present in use.

The foregoing analysis indicates the extent to which the mineral production of Canada is dependent upon the utilization of our water-powers, and emphasizes the fortunate relationship which ensures ample supplies of hydro-electric energy in the mineralized areas.

PAST AND FUTURE GROWTH IN THE UTILIZATION OF WATER-POWER

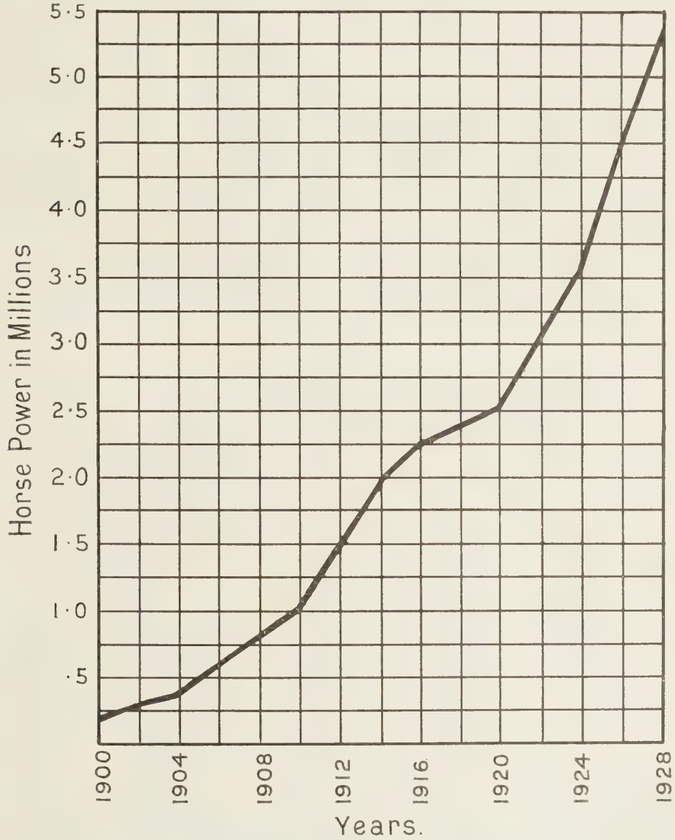
The growth of water-power development in Canada has been most striking, as shown on the diagram on page 39. Total installed horse-power has grown from 977,171 horse-power at the end of 1910 to 5,349,232 horse-power at the end of 1928, central electric station installation from 630,518 horse-power to 4,445,693 horse-power and pulp and paper installation from 151,491 horse-power to 572,976 horse-power in the same period.

There is every reason to believe that the rate of growth will not diminish. New adaptations of electric current of the greatest import in industrial processes and domestic utilization are being constantly developed. Canada's strategic advantage in the location of large reserves of water-power within transmission distance of her centres of population is attracting special industries to these centres in increasing numbers, while opportunity for low-priced development of large blocks of power at more remote sites is creating new centres of population contiguous to the plants for which the power was developed.

CAPITAL INVESTED IN WATER-POWER

The stability of Canadian water-power investments is a subject on which there is much information available from reliable sources. The range of prices of bonds and stocks of leading hydro-electric companies and the dividends paid during the past ten or fifteen years, as shown by the Montreal and Toronto Stock Exchange records, affords convincing evidence of the stability of the capital and the regularity of the interest.

The total outstanding capital invested in water-power development is now about $1,172,600,000 and of this some $999,200,000, or 85 per cent, has been expended on land, buildings, plant and equipment for the generation, transmission and distribution of hydro-electric power. Applied to the existing installation this amounts to an average of $219 per horse-power installed, including transmission and distribution, a low figure compared to that for other countries under similar conditions. In view of the steady earning power shown by the industry even in times of industrial difficulties and depression, it would appear that this capitalization is reasonable and one which the industry is well able to carry.



Water-power development in Canada is no longer speculative but has become a highly specialized process, recognized as such by leading financial houses and by individual investors all over the world and particularly on this continent. That new capital is readily available for enterprises of a promising character, is shown by the remarkable development carried out within the past three years involving expenditures upwards of $227,000,000.

The openings for further investment in Canadian hydro-electric enterprises are likely to be numerous; the resources of raw material are exceptionally varied and abundant; labour conditions are relatively stable; the total manufactures and the proportion of manufactures exported show rapid and sustained increase, while for legitimate power projects governmental co-operation is sympathetic and constructive.

COAL EQUIVALENT OF DEVELOPED WATER-POWER

The development of water-power in Canada has had a direct and very great effect in reducing the consumption of coal and while it is very difficult to assign a precise figure of the coal equivalent of developed water-power as the matter is comparative only and asumptions must necessarily be made dependent upon the conditions under which the power is developed, nevertheless, taking into account all present conditions surrounding water-power development in Canada and comparing them with somewhat similar conditions of fuel development elsewhere it is reasonable to state that a saving of coal of six tons per annum is capable of being effected by each installed horse-power. This means that the total present water-power installation of 5,349,200 horse-power is capable of effecting a saving of about 32,095,000 tons of coal per annum. With the marked economies that are continually taking place in coal consumption in fuel-power stations it will be necessary to adjust from time to time the coal equivalent of developed water-power, but under existing conditions the figure of 32,095,000 tons is not unreasonable.

It has not been the purpose of this survey to cover the subject of Canada's water-powers in detail but merely to indicate briefly their nature, extent and location, their proximity to centres of industry and population and their application and influence in the industrial and domestic life of the Dominion. Water-power has made a substantial contribution to the development of the country and the large resources in accessible undeveloped sites give every promise that its influence upon progress will remain conspicuous for a considerable time to come.

Table 1.—Available and Developed Water Power in Canada January 1, 1929

Province	Available 24-hour power at 80 per cent efficiency		Turbine installation h.p.
	At ordinary min. flow h.p.	At ordinary six months flow h.p.	
1	2	3	4
British Columbia	1,931,000	5,103,500	554,792
Alberta	390,000	1,049,500	34,532
Saskatchewan	542,000	1,082,000	35
Manitoba	3,309,000	5,344,500	311,925
Ontario	5,330,000	6,940,000	1,903,705
Quebec	8,459,000	13,064,000	2,387,118
New Brunswick	87,000	120,800	67,131
Nova Scotia	20,800	128,300	74,356
Prince Edward Island	3,000	5,300	2,439
Yukon and Northwest Territories	125,200	275,300	13,199
Canada	20,197,000	33,113,200	5,349,232

The figures listed in columns 2 and 3 in the above table represent 24-hour power and are based upon rapids, falls and power sites of which the actual existent drop or the head possible of concentration is definitely known or at least well established. Many rapids and falls of greater or lesser power capacity are scattered on rivers and streams from coast to coast which are not yet recorded, and which will only become available for tabulation as more detailed survey work is undertaken and completed. This is particularly true in the less explored northern districts. Nor is any consideration given to the power concentrations which are feasible on rivers and streams of gradual gradient, where economic heads may be created by the construction of power dams, excepting only at such points as definite studies have been carried out and the results made matters of record.

The figures in column 4 represent the actual water wheels installed throughout the Dominion. These figures should not be placed in direct comparison with the available power figures in columns 2 and 3 for the purpose of deducting therefrom the percentage of the available water-power resources developed to date. The actual water-wheel installation throughout the Dominion averages 30 per cent greater than the corresponding maximum available power figures calculated as in column 3. The figures quoted above, therefore, indicate that the at present recorded water-power resources of the Dominion will permit of a turbine installation of about 43,000,000 horse-power. In other words, the present turbine installation represents only a little less than 12½ per cent of the present recorded water-power resources.

The above figures may be said to represent the minimum water-power possibilities of the Dominion.

As illustrative of this detailed analyses which have been made of the water-power resources of the provinces of New Brunswick and Nova Scotia have disclosed most advantageous reservoir facilities for regulating stream flow and it is estimated that the two provinces possess within their respective borders 200,000 and 300,000 commercial horse-power. These figures provide for a diversity factor between installed power and consumers' demands.

Table 2.—Developed Water Power in Canada, Distribution by Industries and per 1,000 Population January 1, 1929

Province	Turbine installation in h.p.				Population June 1, 1928	Total installation per 1,000 population
	In central electric stations	In pulp and paper mills	In other industries	Total		
1	2	3	4	5	6	7
						h.p.
British Columbia	412,960	81,000	60,832	554,792	583,000	952·0
Alberta	34,320	....	212	34,532	631,900	55·0
Saskatchewan	....	....	35	35	851,000	0·04
Manitoba	311,925	....	....	311,925	655,000	476·0
Ontario	1,568,423	240,880	94,402	1,903,705	3,229,000	590·0
Quebec	2,030,850	220,810	135,458	2,387,118	2,647,000	902·0
New Brunswick	43,910	14,278	8,943	67,131	415,000	162·0
Nova Scotia	42,929	16,008	15,419	74,356	547,000	136·0
Prince Edward Island	376	....	2,063	2,439	86,400	28·0
Yukon and Northwest Territories	....	....	13,199	13,199	12,700	1,039·0
Canada	4,445,693	572,976	330,563	5,349,232	9,658,000	554

Column 2 includes only hydro-electric stations which develop power for sale.

Column 3 includes only water-power *actually developed* by pulp and paper companies. In addition to this total pulp and paper companies purchase from the hydro-power central electric stations totalled in column 2 horse-power estimated at about 789,500 horse-power making a total of about 1,362,500 horse-power actually used in the manufacture of pulp and paper.

Column 4 includes only water-power *actually developed* in connection with industries other than the central electric station and pulp and paper industries. These industries also purchase power from the central electric stations totalled in column 2.

Column 5 totals all turbines and water wheels installed in Canada.

Column 6 shows the population at June 1, 1928 as estimated by the Dominion Bureau of Statistics.

Column 7 averages the developed water-power per 1,000 population.

Table 3.—Developed Water-power in Canada Utilized in the Central Electric Station Industry, January 1, 1929

Province	Commercial Stations					Municipal Stations				
	Number of stations	Number of turbines	Total turbine installation h.p.	Average h.-p. per station	Average h.-p. per turbine	Number of stations	Number of turbines	Total turbine installation h.-p.	Average h.-p. per station	Average h.-p. per turbine
1	2	3	4	5	6	7	8	9	10	11
British Columbia	21	48	402,865	19,184	8,393	8	11	10,095	1,262	918
Alberta	5	17	33,360	6,672	1,962	1	2	960	960	480
Saskatchewan	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Manitoba	3	17	206,800	68,933	12,165	2	17	105,125	52,562	6,184
Ontario	68	198	505,388	7,432	2,552	45	137	1,063,035	23,623	7,758
Quebec	89	246	2,009,990	22,584	8,171	13	21	20,860	1,605	993
New Brunswick	3	7	31,850	10,617	4,550	3	6	12,060	4,020	2,010
Nova Scotia	13	17	10,166	782	598	17	27	32,763	1,927	1,213
Prince Edward Island	5	6	376	75	63	.....	.....	.....	.....	.....
Yukon and Northwest Territories	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Canada	207	556	3,200,795	15,463	5,757	89	221	1,244,898	13,988	5,633

Commercial stations include all privately owned.
Municipal stations include all publicly owned.

NOTE.—Statistics in this table are based upon a census of the industry made by the Dominion Bureau of Statistics in co-operation with the Dominion Water Power and Reclamation Service. In addition to the central electric station organizations included above certain industrial hydraulic plants sell small amounts of electricity, i.e., the sale of electricity is only incidental to their main industries.

Table No. 4.—Pulp and Paper Mills in Canada Utilizing Hydraulic or Hydro-Electric Power

BRITISH COLUMBIA

Ref. No.	Organization	River	Location of mills	Direct drive h.-p.	Hydro-electric drive h.-p.	Total hydraulic installation h.-p.	Remarks
	Pulp Mills						
1	British Columbia Pulp and Paper Company, Limited.	Victoria lake	Port Alice	.....	300	300	
2	British Columbia Pulp and Paper Company, Limited.	Mill creek and Cedar creek.	Woodfibre	1,305	935	2,240	
3	British Columbia Pulp and Paper Company, Limited.	Swanson creek	Swanson Bay	850	900	1,750	Not in operation in 1927.
	Pulp and Paper Mills						
4	Pacific Mills Limited	Link	Ocean Falls	9,600	17,250	26,850	500 h.-p. of this sold for Central Station use.
5	Powell River Company, Limited	Powell	Powell River	14,400	35,460	49,860	
6	Sydney Roofing and Paper Company, Limited.	.....	Victoria	.....	.....	.....	Purchase hydro-electricity from British Columbia Electric Railway Company.
	Paper Mills						
7	Westminster Paper Company, Limited	.....	New Westminster	.....	.....	.....	Purchase hydro-electricity from British Columbia Electric Railway Company.
				26,155	54,845	81,000	

MANITOBA

Ref. No.	Organization	River	Location of mills	Direct drive h.-p.	Hydro-electric drive h.-p.	Total hydraulic installation h.-p.	Remarks
	Pulp and Paper Mills						
8	Abitibi Power and Paper Company, Limited (Manitoba Paper Company).	.....	Fort Alexander	.....	.....	.....	Purchase hydro-electricity from Manitoba Power Company.

Table No. 4.—Pulp and Paper Mills in Canada Utilizing Hydraulic or Hydro-Electric Power—Con.

NEW BRUNSWICK

PULP MILLS

Ref. No.	Organization	River	Location of mills	Direct drive h.-p.	Hydro-electric drive h.-p.	Total hydraulic installation h.-p.	Remarks
9	Fraser Companies, Limited	Madawaska	Edmundston		2,060	2,060	
10	Fraser Companies, Limited		Chatham				Purchase hydro-electricity from New Brunswick Electric Power Commission.
11	St. George Pulp and Paper Company (controlled by International Company).	Magaguadavic	St. George	1,900	768	2,668	
12	Nashwaak Pulp and Paper Company, Limited.		Fairville				Purchase hydro-electricity from New Brunswick Electric Power Commission.
	Pulp and Paper Mills						
13	Bathurst Power and Paper Company, Limited (under management of Canadian International Paper Company)	Nepisiguit	Bathurst		9,000	9,000	1,000 h.-p. of this sold for Central Station use.
14	Canadian International Paper		Dalhousie				Under construction. Will purchase hydro-electricity from St. John River Power Company.
				1,900	11,828	13,728	

NOVA SCOTIA

PULP MILLS

Ref. No.	Organization	River	Location of mills	Direct drive h.-p.	Hydro-electric drive h.-p.	Total hydraulic installation h.-p.	Remarks
15	A. P. W. Pulp and Power Company, Limited.		Sheet Harbour				Purchase hydro-electricity from Nova Scotia Power Commission.
16	Clyde Sissiboo Pulp Company, Ltd.	Clyde	Clyde River	1,800		1,800	
17	Clyde Sissiboo Pulp Company, Ltd.	Sissiboo	Weymouth	3,540		3,540	
18	Avon River Power Company	Gaspereau	White Rock	580		580	
19	LaHave Pulp Company, Limited	LaHave	New Germany	1,500		1,500	
20	MacLeod Pulp and Paper Company, Limited.	Liverpool	Milton	6,974		6,974	
21	Nova Scotia Wood Pulp and Paper Company, Limited.	Medway	Charleston	1,614		1,614	

PULP AND PAPER MILLS

22	Mersey Paper Company, Limited	....	Liverpool........	....	....	....	Under construction. Power to be purchased from Nova Scotia Power Commission.
				16,008	....	16,008	

ONTARIO

PULP MILLS

23	Davey Pulp and Power Company....	Welland canal......	Thorold........	1,180	....	1,180	
24	Bronson Company........	Ottawa........	Ottawa........	2,000	....	2,000	
25	Great Lakes Paper Company, Limited	....	Fort William........	....	....	....	Purchase hydro-electricity from Hydro-Electric Power Commission of Ontario.
26	Hydro-Electric Power Commission of Ontario.	....	Campbellford........	....	....	....	Purchase hydro-electricity from Hydro-Electric Power Commission of Ontario.
27	Manitoulin Pulp Company, Limited..	Kagawong........	Kagawong, Manitoulin, Id.	1,400	150	1,550	
28	Abitibi Power and Paper Company, Limited, Smooth Rock Falls Division.	Mattagami........	Smooth Rock Falls.	350	9,000	9,350	
29	Nipigon Corporation, Limited........	....	Nipigon........	....	....	....	Purchase hydro-electricity from Hydro-Electric Power Commission of Ontario.
30	Northern Ontario Light and Power Company, Limited.	....	Haileybury........	....	....	....	Purchase hydro-electricity from Northern Ontario Light and Power Company.
31	Canadian International Paper Company.	....	Hawkesbury........	....	....	....	Purchase hydro-electricity from Gatineau Electric Light Company.
32	Canadian International Paper Company.	Welland canal......	Merriton........	650	....	650	Not operated in 1927.
33	Thorold Paper Compapy, Limited...	Welland canal......	Thorold........	614	....	614	
34	Canadian Cellulose Company........	....	Cornwall........	....	....	....	Purchase hydro-electricity from Hydro-Electric Power Commission of Ontario.

Table No. 4.—Pulp and Paper Mills in Canada Utilizing Hydraulic or Hydro-Electric Power—Con.

ONTARIO—*Concluded*

PULP AND PAPER MILLS

Ref. No.	Organization	River	Location of Mills	Direct drive h.-p.	Hydro-electric drive h.-p.	Total hydraulic installation h.-p.	Remarks
35	Abitibi Power and Paper Company, Limited, Iroquois Falls Division.	Abitibi	Iroquois Falls	20,000	38,000	58,000	Hydro-electricity also purchased from Abitibi Electrical Development Company.
36	Abitibi Power and Paper Company, Limited, Fort William Division.		Fort William				Hydro-electricity purchased from Kaministiquia Power Co.
37	Abitibi Power and Paper Company, Limited, Sault Ste. Marie Division.	St. Mary	Sault Ste. Marie	14,400		14,400	Hydro-electricity purchased from Great Lakes Power Company.
38	Abitibi Power and Paper Company, Limited, Espanola Division.	Spanish	Espanola	12,400	8,400	20,800	Hydro-electricity also purchased from International Nickel Company.
39	Abitibi Power and Paper Company, Limited, Sturgeon Falls Division.	Sturgeon	Sturgeon Falls	10,740	13,050	23,790	
40	Beaver Wood Fibre Company, Limited.		Thorold				Purchase hydro-electricity from Hydro-Electric Power Commission of Ontario.
41	Booth, J. R., Limited	Ottawa	Ottawa	14,789	14,000	28,789	
42	Canadian Paperboard Company, Limited.		Frankford				Hydro-electricity purchased from Quinte and Trent Valley Power Company.
43	Dryden Paper Company, Limited	Wabigoon and Eagle	Dryden	2,100	1,400	3,500	About 30 h.p. sold for central electric station use.
44	Fort Francis Pulp and Paper Company, Limited.	Rainy	Fort Francis	8,550		8,550	6,800 h.p. additional in this Plant for Central Electric Station use.
45	Kenora Paper Mills Limited		Kenora				Purchase hydro-electricity from Keewatin Power Company.
46	Lincoln Pulp and Paper Mills, Limited.	Welland	Merritton	989	1,100	2,089	
47	Provincial Paper Mills, Limited		Port Arthur				Purchase hydro-electricity from Hydro-Electric Power Commission of Ontario.
48	Ontario Paper Company, Limited		Thorold				Purchase hydro-electricity from Hydro-Electric Power Commission of Ontario.
49	Smith, Howard, Paper Mills Limited	Cornwall canal	Cornwall	1,238		1,238	Purchase hydro-electricity from Hydro-Electric Power Commission of Ontario.

50	Spruce Falls Power and Paper Company, Limited.	Kapuskasing	Kapuskasing	....	2,500	2,500	200 h.p. sold for central station use.
			Smoky Falls	....	56,250	56,250	
51	Thunder Bay Paper Company	Mattagami	Port Arthur	....	....	....	Purchase hydro-electricity from Hydro-Electric Power Commission of Ontario.
52	Adams Cellboard Company, Limited	Flamboro creek	Greenville	105	....	105	
53	Canadian Paperboard Company, Limited.	....	Campbellford	....	....	....	Purchase hydro-electricity from Quinte and Trent Valley Power Company.
54	Canadian Paperboard Company, Limited.	....	Toronto	....	....	....	Purchase hydro-electricity from Toronto Hydro-Electric Power Commission.
55	Garden City Paper Mills, Limited	Old Welland canal	St. Catharines	285	....	285	
56	Hastings Paper Mills, Limited	Moira	Belleville	90	....	90	
57	Hinde & Dauch Paper Company, Limited.	....	Toronto	....	....	....	Purchase hydro-electricity from Toronto Hydro-Electric Power Commission.
58	Hinde & Dauch Paper Company, Limited.	....	Trenton	....	....	....	Purchase hydro-electricity from Hydro-Electric Power Commission of Ontario.
59	Kinleith Paper Mills, Limited	Old Welland canal	St. Catharines	605	....	605	Not operating.
60	Manson Limited	....	Hawkesbury	....	....	....	Purchase hydro-electricity from Gatineau Electric Light Company.
61	Miller Bros., Limited	Trent	Glen Miller	494	190	684	
62	Provincial Paper Mills, Limited	Credit	Georgetown	65	150	215	Purchase hydro-electricity from Hydro-Electric Power Commission of Ontario.
63	Provincial Paper Mills, Limited	....	Mille Roche	....	....	....	Purchase hydro-electricity from St. Lawrence Power Company.
64	Provincial Paper Mills, Limited	Old Welland canal	Thorold	453	1,040	1,493	
65	Superior Paper Mills, Limited	....	Thorold	....	....	....	Purchase hydro-electricity.
66	Strathcona Paper Company, Limited.	Napanee	Strathcona	153	....	153	
67	Dominion Boxboards Limited	....	Toronto	....	....	....	Not yet operating. Purchase hydro-electricity from Toronto Hydro-Electric Power Commission.
68	Don Valley Paper Company	....	Todmorden	....	....	....	Purchase hydro-electricity from Toronto Hydro-Electric Power Commission.
69	Interlake Tissue Mills, Limited	....	Merroitton	....	....	....	Purchase hydro-electricity from Hydro-Electric Power Commission of Ontario.
				93,650	145,230	238,880	

Table No. 4.—Pulp and Paper Mills in Canada Utilizing Hydraulic or Hydro-Electric Power—Con.

QUEBEC

PULP MILLS

Ref. No.	Organization	River	Location of mills	Direct drive h.-p.	Hydro-electric drive h.-p.	Total hydraulic installation h.-p.	Remarks
70	Atkinson, Henry, Limited	Etchemin	Pont Etchemin	1,113		1,113	
71	Brown Corporation	St. Maurice	La Tuque		4,400	4,400	
72	Brown Corporation, Limited	Madeleine	Madeleine River Gaspe.	5,330	600	5,930	Not operating in 1927.
73	Quebec Pulp and Paper Company, Limited.	Chicoutimi	Chicoutimi	20,220		20,220	
74	Quebec Pulp and Paper Company, Limited.	Ouiatchouaniche	Val Jalbert	6,300	1,000	7,300	Purchase hydro-electricity from La Societe d'Eclairage et d'Energie Electrique de Saguenay.
75	Gulf Pulp and Paper Company, Limited.	St. Marguerite	Clarke City	10,100	860	10,960	
76	Lotbiniere-McCrea-Baker Inc.	Nicolet	Danville	1,680		1,680	
77	Lake Megantic Pulp Company, Limited.	Chaudiere	Lake Megantic	1,550		1,550	
78	MacLaren, The James Company, Limited.	Lievre	Buckingham	6,850		6,850	
79	Metabetchouan Sulphite and Pulp Company, Limited.		Desbiens				Purchase hydro-electricity from Duke-Price Power Company.
80	Price Bros. & Company	Rimouski	Beausejour	3,150		3,150	
81	Canadian International Paper Company.		Temiskaming				Hydro-electricity purchased from Gatineau Electric Light Company.
82	Soucy, F. Flo	Loup	Old Lake Road	800		800	
83	Warren Company, Limited	Loup	Riviere du Loup	3,500		3,500	
84	Wilson, J. C., Limited	North	St. Jerome	1,090		1,090	
85	Anglo-Canadian Pulp and Paper Company, Limited.		Limoilou				Hydro-electricity purchased from Shawinigan Water and Power Company.
86	Canada Power and Paper Corporation, Belgo Division.	St. Maurice	Shawinigan Falls	14,810	3,100	17,910	Hydro-electricity purchased from Shawinigan Water and Power Company.
87	Canada Power and Paper Corporation, Windsor Mills.	St. Francis Watopeka.	Windsor Mills	5,690	300	5,990	
88	Canada Power and Paper Corporation, Laurentide Company Mills.		Grand'Mere				Hydro-electricity purchased from Laurentide Power Company.

89	Canada Power and Paper Corporation, St. Maurice Division.	....	Three Rivers.......	....	....	....	Hydro-electricity purchased from Shawinigan Water and Power Company.
	Pulp and Paper Mills						
90	Brompton Pulp and Paper Company, Bromptonville Mill.	St. Francis..........	Bromptonville......	10,316	....	10,316	Hydro-electricity purchased from Shawinigan Water and Power Company.
91	Brompton Pulp and Paper Company, East Angus Mill.	St. Francis..........	East Angus.........	10,701	....	10,701	
92	Dominion Paper Company...........	Nicolet.............	Kingsey Falls.......	880	....	880	
93	Donnacona Paper Company..........	Jacques Cartier.....	Donnacona..........	....	6,000	6,000	
94	Eddy, E. B., Company, Limited.....	Ottawa.............	Hull................	....	13,500	13,500	
95	Price Bros. & Company, Limited, Jonquiere Mill.	Au Sauble and Chicoutimi.	Jonquiere...........	4,500	11,000	15,500	Hydro-electricity purchased from Shipshaw Power Company.
96	Price Bros. & Company, Limited, Kenogami Mill.	Au Sauble and Shipshaw.	Kenogami..........	19,200	24,600	43,800	Hydro-electricity purchased from Shipshaw Power Company.
97	Price Bros. & Company, Limited, Riverbend Mill.	....	Riverbend..........	....	....	....	Purchase hydro-electricity from Duke-Price Power Company.
98	News Pulp and Paper Company, Limited.	Ste. Anne...........	St. Raymond.......	2,480	1,600	4,080	Purchase hydro-electricity from Shawinigan Water and Power Company.
99	St. Lawrence Paper Mills, Limited...	....	Three Rivers.......	....	....	....	Purchase hydro-electricity from Shawinigan Water and Power Company.
100	Canadian International Paper Company, Gatineau Mill.	....	Gatineau..........	....	....	....	Purchase hydro-electricity from Gatineau Electric Light Company.
101	Canadian International Paper Company, Three Rivers Mill.	....	Three Rivers.......	....	....	....	Purchase hydro-electricity from Shawinigan Water and Power Company.
102	Smith, Howard, Paper Mills, Limited	Lake Ouareau.......	Crabtree Mills......	....	1,200	1,200	
103	Wayagamack Pulp and Paper Company, Limited.	....	Three Rivers.......	....	....	....	Purchase hydro-electricity from Shawinigan Water and Power Company.
104	Abitibi Power and Paper Company, Limited (Ste. Anne Paper Company, Limited).	....	Ste. Anne de Beaupre	....	....	....	Purchase hydro-electricity from Shawinigan Water and Power Company.
105	Abitibi Power and Paper Company, Limited (Murray Bay Paper Company, Limited).	Malbaie............	Murray Bay........	9,000	....	9,000	
106	Lake St. John Power and Paper Company.	....	Dolbeau...........	....	....	....	Purchase hydro-electricity from Lake St. John Light and Power Company and from Duke-Price Company.
107	Port Alfred Pulp and Paper Corporation.	Ha Ha.............	Port Alfred.........	....	2,100	2,100	Purchase hydro-electricity from Duke-Price Power Company.

Table No. 4.—Pulp and Paper Mills in Canada Utilizing Hydraulic or Hydro-Electric Power—Con.

QUEBEC—*Concluded*

PAPER MILLS

Ref. No.	Organization	River	Location of Mills	Direct drive h.-p.	Hydro-electric drive h.-p.	Total hydraulic installation h.-p.	Remarks
108	Back River Power Company, Limited	....	Sault au Recollet	....	....	....	Purchase hydro-electricity from Montreal Light, Heat and Power Consolidated.
109	Barry Fibre Company, Inc	....	Chateau Richer	126	....	126	Purchase hydro-electricity from Shawinigan Water and Power Company.
110	Building Products Limited, Bird Division.	Jacques Cartier	Pont Rouge	1,384	....	1,384	
111	Building Products Limited, Rubberoid Division.	Portneuf	Portneuf	340	....	340	Purchase hydro-electricity from Shawinigan Water and Power Company.
112	Bishop & Sons, Limited	Portneuf	Portneuf Station	250	....	250	Purchase hydro-electricity from Shawinigan Water and Power Company.
113	Canadian Paperboard Company, Limited.	Lachine canal	Montreal	....	180	180	
114	Ford, Joseph, & Company, Limited	Portneuf	Portneuf Station	290	....	290	Purchase hydro-electricity from Shawinigan Water and Power Company.
115	Barrett Company Limited	L'Assomption	Joliette	283	....	283	
116	Rolland Paper Company, Limited	North	Mont Rolland	1,325	....	1,325	
117	Rolland Paper Company, Limited	North	St. Jerome	700	....	700	Purchase hydro-electricity from Gatineau Electric Light Company.
118	Smith, Howard, Paper Mills, Limited	....	Beauharnois	....	....	....	Purchase hydro-electricity from Shawinigan Water and Power Company.
119	Western Quebec Paper Mills, Limited	....	St. Andrews East	....	....	....	Purchase hydro-electricity from Gatineau Electric Light Company.
120	Wilson, J. C., Limited	North	Lachute Mills	1,208	....	1,208	
121	Eastern Paper and Felt Mills Corporation.	Portneuf	St. Basile	130	....	130	Purchase hydro-electricity from Shawinigan Water and Power Company.
122	International Fireboard Company, Limited.	....	Gatineau	....	....	....	Purchase hydro-electricity from Gatineau Electric Light Company.
	Canada	....	....	283,009	282,343	565,352	

Table 5.—H.P. of Motors Driven by Purchased Electricity

Province	Horse-power of motors
Quebec	566,371
Ontario	185,472
All other provinces	37,687
Total	789,530

Table 6.—Electricity Purchased, Amount and Cost

Province	Value of power	Amount and Cost of Power Purchased			
	$	$	Kwh. 000's of	$	h.p.
Quebec	7,659,244	6,461,638	2,352,547	1,197,606	93,219
Ontario	3,296,919	1,872,089	571,721	1,424,830	135,927
All other provinces	530,658	213,036	140,577	317,622	26,585
Canada	11,486,821	8,546,763	3,064,845	2,940,058	255,731

Table 7.—Available Pulp Wood and Water Power of Canada

Province	Estimated pulp wood resources million cords	Available water power at ordinary minimum flow h.p
British Columbia	290	1,931,000
Alberta	252	390,000
Saskatchewan	142	542,000
Manitoba	67	3,309,000
Ontario	200	5,330,000
Quebec	330	8,459,000
New Brunswick	35	87,000
Nova Scotia	28	20,800

CENSUS OF THE CENTRAL ELECTRIC STATION INDUSTRY

Canada's central electric station industry, the generation or distribution of electrical energy for public use, has attained record proportions because the wide distribution and accessibility of her abundant water-powers is such that with modern methods of transmission, low cost hydro-electricity for industrial, agricultural and domestic use is available to all but a small proportion of her population, while, in the sections remote from water-power, abundant supplies of native fuels supply or constitute potential sources of electricity.

The certainty of the supply of power and the assurance of its continuance at uniform or lower rates through the medium of the central stations has done much to attract industries which would not in the ordinary course engage in the production of their own power.

In the central electric station industry over 95 per cent of the primary power equipment is energized by falling water, while the diversity of use of hydro-electricity induced by moderate prices results in almost 99 per cent of the total electrical output being generated in the hydraulic stations.

The foregoing facts premise the importance to this service of the frequent periodic revision of all basic data relating to the central electric station industry and this revision is accomplished through the medium of an annual census inaugurated by the Dominion Water Power and Reclamation Service and conducted in co-operation with the Dominion Bureau of Statistics of the Department of Trade and Commerce.

The general statistics of this census are made available through annual reports issued by the Dominion Bureau of Statistics while at longer intervals a Directory of Central Electric Stations presenting a comprehensive review of the scope and character of all organizations, commercial or municipal, distributing electricity for sale, is published. The various aspects of personnel; capital invested; generating, transmitting and distributing equipment used; power generated, purchased and sold; blocks of power available for sale, rates and transportation facilities are presented in a form that renders the Directory a highly valuable reference to the extensive financial and technical interests concerned with the industry.

The general statistical review of the eleventh annual census, that for the calendar year 1927, will shortly appear in preliminary form and will be followed later by the final report, while the third issue of the Directory descriptive of conditions obtaining May 1, 1928, is daily expected from the printers.

DOMINION HYDROMETRIC SURVEY

The Dominion Hydrometric Survey embraces stream measurement work throughout Canada. The records are brought together in one central agency, which attends to the compilation and dissemination of stream-flow data and the survey operates efficiently both as regards office administration and field operations.

In the Prairie Provinces the work is the direct responsibility of the Dominion Government and in the other provinces the survey is carried on by the Dominion Government under co-operative agreements with the provinces concerned. The Dominion is divided into major drainage divisions, which, together with the district office or offices in charge, are as follows: Pacific drainage, Vancouver; Arctic and Western Hudson Bay drainage, Calgary and Winnipeg; St. Lawrence and Southern Hudson Bay drainage, Ottawa and Montreal; Atlantic drainage, Halifax.

The uses to which the records are put are primarily in connection with water-power development and irrigation projects, and the rapid strides which have taken place in the hydro-electric field are due in no small part to the detailed and extensive records of the regimen of the numerous lakes and rivers of the country which have been made available, by the Dominion Hydrometric Survey, assisted by the voluntary co-operation of the provinces, of private corporations and of numerous individuals.

Run-Off Conditions in Canada

As set forth in detail in the annual reports of the District Chief Engineers, the average run-off for the year has been generally normal in the Pacific, Arctic and Western Hudson Bay and Atlantic drainages, and above normal in the St. Lawrence and Southern Hudson Bay drainage.

In the Pacific drainage typical stations showed a range in run-off for the year from 64 per cent of the long term mean in Capilano creek in the coast region to 114 per cent of the long term mean in the Kootenay river at Wardner.

In the Arctic and Western Hudson Bay drainage typical stations showed a range in run-off for the year from 37 per cent of the long term mean in the Swan river in Manitoba to 127 per cent of the long term mean in the Assiniboine river in Manitoba.

In the St. Lawrence and Southern Hudson Bay drainage typical stations showed a range in run-off for the year from 131 per cent of the long term mean in the St. Maurice river in Quebec to 200 per cent of the long term mean in the Missinaibi river in northern Ontario.

In the Atlantic drainage typical stations showed a range in run-off for the year from 93 per cent of the long term mean in the La Have river in south-western Nova Scotia to 103 per cent of the long term mean in the St. Mary river in eastern Nova Scotia.

FIELD REPORTS

DISTRICT OF BRITTISH COLUMBIA

C. E. Webb, District Chief Engineer

Systematic stream-flow and water-power studies were continued in the British Columbia district by the Dominion Water Power and Reclamation Service, during the fiscal year ending March 31, 1929, in accordance with the terms of the co-operative agreement existing between the Department of the Interior and the Government of British Columbia.

Organization

The work of the Dominion Water Power and Reclamation Service is directed from the office of the District Chief Engineer at 739 Hastings street, west, Vancouver. To facilitate field operations in the interior, a division office is maintained at Kamloops and a sub-office at Nelson. While the acquisition and tabulation of stream-flow data for use in connection with the study of irrigation, reclamation, domestic water-supply and power development, is the outstanding work of the organization, this service is also called upon to supervise and prosecute engineering investigations and projects on behalf of other federal Government departments.

Considerable engineering assistance has been given to the Department of Indian Affairs in connection with the adjustment of Indian water rights in British Columbia, as well as in the construction of irrigation, drainage, domestic water-supply and sewage disposal projects, river bank protection works and electric lighting plants for Indian reserves, villages and Indian residential schools. During the past year, three engineering parties have been maintained in the field while relative matters have been dealt with in the district office.

Co-Operation

All stream-flow studies in British Columbia are made by this Service under the terms of the co-operative agreement with the province. A complete record of all hydrometric data is annually supplied to the Comptroller of Water Rights at Victoria and the District Water Rights Engineers throughout the province. Close co-operation has been maintained with the Water Resources Branch of the United States Geological Survey on important international waters including the Kootenay, Columbia, Pend d'Oreille (Clark Fork) and Okanagan rivers. It is proposed to extend stream-flow studies on international streams to cover all the important rivers crossing the boundary west of the Rocky mountains

Close co-operation has been maintained with the Greater Vancouver Water District in their studies on Capilano and Seymour creeks in connection with a metropolitan domestic water-supply for Greater Vancouver area.

Stream-flow studies have been continued on Brunette river at the outlet of Burnaby lake in co-operation with the Vancouver and District Joint Sewerage and Drainage Board.

Five gauging stations have been maintained in the Bridge River district in co-operation with the Bridge River Power Company while miscellaneous records have been obtained on important streams in that area.

Close co-operation has been maintained with the city of Vancouver continuing the special hydrometric investigations on power streams within reasonable transmission distance from Vancouver.

A study of the velocity of tides through Seymour narrows near Campbell river was carried out in co-operation with the Federal Department of Public Works as well as a study of tides under the Second Narrows bridge in Vancouver harbour in co-operation with the Burrard Inlet Tunnel and Bridge Company.

Co-operative investigations with hydro-electric power companies have expanded most satisfactorily during the year. Some of these include: the East Kootenay Power Company, on the Elk and Bull rivers; the West Kootenay Power and Light Company, on Kootenay river; the Canadian Crown Willamette Company, Limited, on the Campbell river; the Canadian Forest Products Limited, on the Nimpkish river and the Pacific Mills Limited on the Nascall and Dean rivers.

Irrigation districts throughout the interior are afforded close co-operation in connection with the study of their water supply.

During the year, close co-operation was maintained with the Dominion Lands Administration. Investigations have been made and reports with plans submitted, when required, in connection with lands in the Railway Belt of British Columbia.

Hydraulic studies of the Fraser river at Hell's Gate and Bridge River canyon have been continued during the year at the request of the Department of Marine and Fisheries in connection with the migration of salmon to their spawning grounds.

International waterway problems have ben studied on the Kootenay and Pend d'Oreille rivers.

As in previous years, a large amount of engineering work has been done in co-operation with the Department of Indian Affairs. This work covers an extensive range of engineering problems concerning the use and distribution of water. During the year, three conditional licences have been obtained for the Department of Indian Affairs for the diversion of water for use on Indian reserves, while many problems were considered on streams where conditional water-rights have already been obtained. As all the works necessary under Conditional Licences granted by the provincial authorities must be completed within a specified time, close engineering supervision is necessary in order that the full benefit of water held under Conditional Licences may be obtained under a Final Water Record.

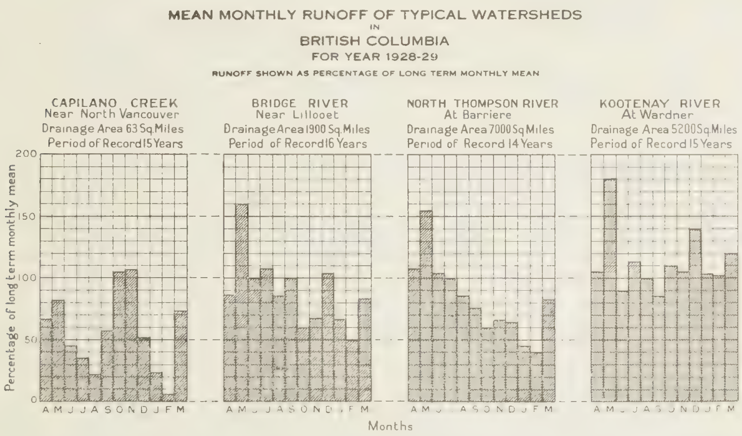
Hydrometric Survey

Two hundred and forty-four gauging stations were maintained for the whole or part of the year ending March 31, 1929, on rivers, tributaries or lakes in the following main watersheds: Columbia, Fraser, Kettle, Kootenay, North Thompson, Okanagan, Pacific coast (Mainland), Pacific coast (Vancouver island), Similkameen, South Thompson, Thompson and Skeena. While the total number of stations operated was slightly less than in 1928, the area covered was greatly increased. Many of these stations were maintained for more than one purpose, 98 were maintained for power, 143 for irrigation, 20 for drainage and reclamation, 17 for domestic water supply, 32 for flood warning purposes, 23 for navigation, 23 in connection with international problems and 13 for statistical purposes. There were 69 new stations established and 77 discontinued. Of the new stations, 67 were established at the request of the Provincial Water Rights Branch in connection with water-power investigations and irrigation problems throughout the province, one was established at the request of the Greater Vancouver Water District in connection with the study of water-supply for that district and one in connection with the power problems in the east Kootenay district. At several of these stations automatic gauges and measuring cables were installed. In addition to the gauging stations established, there were 4 evaporation stations opened at selected points in the province.

Temperatures were generally below normal in the province due to exceptionally cold weather in January and February. In certain portions of the coast area they were slightly above normal due to high summer temperatures in 1928. Precipitation was generally below normal and this was especially so in the coastal area.

Run-off varied considerably in different portions of the province during the year. Due to heavy snowfall in the winter of 1927-28, the run-off during the summer season of 1928 was above normal in the interior. The generally low precipitation has resulted in unprecedented low run-off in the coastal area particularly during the winter of 1928-29. This unprecedented condition is causing hydro-electric companies along the coast considerable anxiety as their storages are now exhausted at a time when they are usually overflowing. Plate 2 shows in graphic form the run-off each month as a percentage of the long term monthly mean for the following typical stations in the Pacific drainage: Capilano creek near Vancouver, Bridge river near Lillooet, North Thompson river near Barriere, and the Kootenay river at Wardner.

PLATE 2



The typical stream for the coastal area is Capilano creek, which has a drainage area of 64 square miles. Low precipitation and run-off were recorded during the year, each being 64 per cent of the long term mean. Flood run-off reached a maximum daily discharge of 123 second-feet per square mile in January, as compared with 264 second-feet in October, 1921. The minimum run-off, which occurred in August, was at a rate of 0·39 second-foot per square mile, or lower than the previous daily minimum of 0·47 second-foot per square mile in October, 1925 and August, 1926.

In the Central Fraser basin, as typified by Bridge river, which has a drainage area of 1,900 square miles, precipitation was below average although run-off was normal, the former being 69 per cent of the long term mean and the latter 100 per cent. The flood run-off reached a maximum daily mean discharge of 7·95 second-feet per square mile in June, compared with 13·7 second-feet in June, 1913. The low run-off, which occurred in February, was at the rate of 0·12 second-foot per square mile, as compared with the previous low of 0·09 second-foot in November, 1925.

The North Thompson river at Barriere (typical of its river basin) with a drainage area of 7,000 square-miles had a normal run-off although the yearly precipitation in the area was below normal, the run-off being 100 per cent and the precipitation 68 per cent of the long term mean. The flood run-off reached

a maximum daily mean discharge of 11·04 second-feet per square mile in May, compared with 11·16 second-feet in June, 1921. The low run-off, which occurred in February, was at the rate of 0·15 second-foot per square mile or lower than the minimum of 0·21 second-foot in February and March, 1919.

In the Upper Kootenay basin, as typified by the Kootenay river at Wardner, which has a drainage area of 5,200 square miles, the yearly precipitation was below normal, while the run-off was above normal, the former being 96 per cent of the long term mean, while the latter was 114 per cent. The flood run-off reached a maximum daily mean discharge of 9·04 second-feet per square mile in May, as compared with 13·0 second-feet in June, 1916. The low run-off, which occurred in March, was at the rate of 0·28 second-foot per square mile, as compared with 0·12 second-foot in January, 1914, the lowest so far recorded.

Special Investigations

Stream-flow studies in co-operation with the city of Vancouver, the Greater Vancouver Water District, irrigation districts, and co-operative investigations with different hydro-electric power companies throughout British Columbia, have already been instanced.

The intensive study of the hydraulic features of the Kootenay drainage from the international boundary to several miles below Nelson was continued throughout the year. Special attention is now being given to a study of the flow in the West Arm of Kootenay lake and in the Kootenay river to a point below Taghum.

A flood warning service was maintained on the Fraser river in anticipation of extremely high water, which did occur at the end of May and beginning of June. The information from this flood warning service was particularly useful in anticipating flood conditions along the fertile lands near the river's mouth.

Investigation was made and report prepared for the Dominion Lands Branch of the Department of the Interior in connection with an application for the foreshore rights at the mouths of the Serpentine and Nicomekl rivers where oyster beds are located.

An investigation and report was also prepared on behalf of the Soldier Settlement Board dealing with damage to lands near Malakwa from Yard creek.

As previously stated, a large amount of engineering work was done on behalf of the Department of Indian Affairs covering investigations and construction work. Many phases of engineering were covered including water storage, irrigation, domestic water-supply, sewage disposal, river bank protection work and electric lighting.

Reports with plans and estimates of cost have been submitted on many different projects for construction by the Indian Department. The following may be instanced as indicating the nature and variety of the different projects reported upon during the year.

Water Storage.—In connection with the irrigation of Soda Creek, I.R. No. 2, an earth filled dam was constructed at the outlet of Rose lake, 680 feet long with maximum height of 12 feet, containing approximately 2,200 cubic yards of material. A specially designed intake tower was necessary to allow the passing of the natural flow of the stream during the irrigation season, storage of flood water only being allowed under licence. The cost per acre-foot of storage on this project amounted to eighty cents.

Irrigation.—At Dog Creek I.R No. 2, an irrigation system was built entailing the erection of 5 flume units of a total length of 3,150 feet, the digging of 5 ditch units of a total length of 5,900 feet and the construction of a diversion

weir in Dog creek at the intake of the system. The system was designed and built for a capacity of 2·5 cubic-feet per second. In carrying out this project it was necessary to relocate one mile of public highway which was done with the co-operation of the Provincial Public Works Engineer. Seventy-five acres of land will be served by this project.

Domestic Water Supply.—A water-supply system for domestic use and fire protection has been installed in the large new Indian Residential school at Kamloops. This project called for the installation of a 60-horsepower motor directly connected to a centrifugal pump situated in a concrete pump house on the north bank of the South Thompson river, immediately behind the new school buildings. The pump has a capacity of 500 gallons per minute and supplies water to a concrete reservoir of 18,000 gallons capacity, constructed on the high ground behind the school. The reservoir stores water for domestic purposes and for immediate use in the event of fire until such time as the pump may be placed in operation, after which the reservoir may, by means of valves, be cut out of the system and the pump used to supply water direct at high pressure to 4 hydrants situated in close promimity to the school buildings. By this method, water is available for domestic use at a pressure of 40 pounds per square inch and for fire protection at a pressure of 78 pounds. Steel pipe has been used throughout for the conveyance of water.

Sewage Disposal.—A sewage disposal plant is being provided for the new Indian Residential school at Albert Bay. It is proposed to locate the outfall of the sewer in the sea near low tide. The system has been so designed that a septic tank may be added if deemed desirable, without disturbing the present arrangements.

River Bank Protection.—Consideration has been given to river bank improvements at St. Mary I.R. No. 1 on the St. Mary river near Cranbrook and it is proposed to carry out a systematic program of improvements over a period of years in order to confine the St. Mary river to its present channel and save the lands of the reserve from further erosion.

Electric Lighting.—In connection with a water-supply system installed during the year at the Christie Indian Residental school on Meares island in Clayoquot sound, on the west coast of Vancouver island, a small hydro-electric power plant was installed developing 3½ kilowatts which is sufficient to take care of lighting requirements at the school. The installation consisted of an extension from the gravity water system, the effective head being 160 feet. The installation consisted of a generator set and panel switchboard suitably housed in the vicinity of the school.

Hydro-electric power development throughout the province of British Columbia has made very satisfactory progress during the past year while the number of enquiries into power possibilities has noticeably increased. The necessity for accurate and continuous stream-flow data in connection with water problems is more strongly evidenced than ever before, while hydrometric records from this service are constantly referred to by the provincial authorities in adjudication of water rights.

DISTRICT OF ALBERTA AND SASKATCHEWAN

Water Power and Hydrometric Survey

The stream measurement and power investigatory work of the Dominion Water Power and Reclamation Service in Alberta and Saskatchewan was continued in conjunction with the Irrigation and Drainage activities referred to in Part III of this report, during the fiscal year ending March 31, 1929.

The whole of the province of Alberta, most of the province of Saskatchewan, and a small portion of northeastern British Columbia is covered from this district office. As lines of communication with the Peace River Block in British Columbia are through Alberta, work in this area is handled from this office and for the same reason the northeastern or Churchill river area in Saskatchewan is under the supervision of the Manitoba office of the Service.

Organization

With the amalgamation of the Dominion Water Power and the Reclamation Service in 1923, it became possible to combine all functions pertaining to the investigation, utilization, and administration of water resources in the provinces of Alberta and Saskatchewan under the control of a single field organization with headquarters in the Southam Building at Calgary. As a matter of economy in administering so large a territory, sub-districts have been created and each placed under the charge of an engineer who carries on the hydrometric field investigations in conjunction with those relating to irrigation, drainage, or water-power. These officers report to, and are instructed from Calgary where all data are collected, compiled, and filed.

CO-OPERATION

The arrangements with the Montana Division of the United States Geological Survey and the United States Bureau of Reclamation for co-operation in regard to the collection of stream-flow records on international waters along the boundary were continued. These duties arise through the appointment of an engineer from this Service to co-operate with an engineer of the United States for the purpose of undertaking the measurement and apportionment of the flow in the St. Mary and Milk rivers and their tributaries in the provinces of Alberta and Saskatchewan, and in the state of Montana, as provided in an Order of the International Joint Commission dated October 4, 1921, in conformity with Article VI of the Boundary Waters Treaty of 1909.

In the investigation of hydrometric problems in connection with the operation of the Lethbridge Northern Irrigation District, active co-operation was maintained with officials of the district. The usual co-operation with officials of other irrigation and power projects in regard to stream and canal flow problems was continued with excellent results.

The co-operative arrangements with other federal departments, the provincial Governments, railway corporations, and several municipalities have been continued during the year. Many phases of the water-supply problems of these organizations have been studied and with their assistance valuable hydrometric data have been obtained which, in addition to their special interest, are also of general value.

The usual demonstrations in connection with hydrometric methods were carried out for the benefit of the students of the Universities of Alberta and Saskatchewan.

Co-operation with Department of Indian Affairs

Construction of the water supply and sewage disposal system for the Indian residential school recently erected at Onion lake north of Lloydminster in Saskatchewan was begun in June and completed in October. The work was done by contract at a total cost of $17,501.78 according to plans and estimates prepared under the direction of the Commissioner of Irrigation and carried out under the supervision of his staff. In September an inspection was made of the water-supply, electric lighting and sewerage systems at the Indian hospital at Ile a la Crosse in northern Saskatchewan and a report prepared suggesting certain

changes and improvements with particular reference to water-supply and fire-protection which has been approved by the Indian Department. During the winter, machinery and materials have been shipped in to the hospital over the ice and the construction work will be done during the coming summer.

Hydrometric Survey

During the fiscal year ended March 31, 1929, 269 gauging stations were maintained on rivers, lakes, canals, and ditches in the following main watersheds: Assiniboine, Athabaska, Battle creek, Belly, Bow, Frenchman, Little Bow, Lodge creek, Milk, North Saskatchewan, Oldman, Peace, Red Deer, Rock creek, Ross creek, St. Mary, Saskatchewan, Sevenpersons creek, South Saskatchewan, Swift Current creek, and Waterton. Of these 50 were all-year stations maintained as follows: 15 for power, 13 for irrigation, 4 for drainage, 6 for domestic water-supply, 5 for international studies, and 7 for statistical purposes. The remaining 219 stations were in operation during the open water season only and for the following purposes: 1 for power, 142 for irrigation, 20 for drainage, 5 for domestic water-supply, 7 for flood warnings, 36 for international purposes, and 8 for statistical information. In addition to these, miscellaneous measurements were obtained at 61 other points.

Plate 3

MEAN MONTHLY RUNOFF OF TYPICAL WATERSHEDS
IN
ALBERTA
FOR YEAR 1928-29
RUNOFF SHOWN AS PERCENTAGE OF LONG TERM MONTHLY MEAN

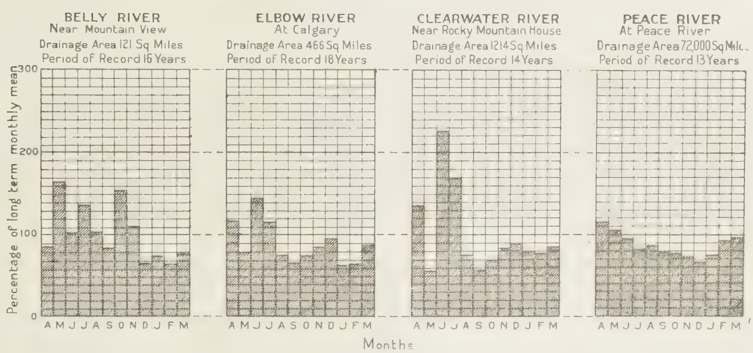
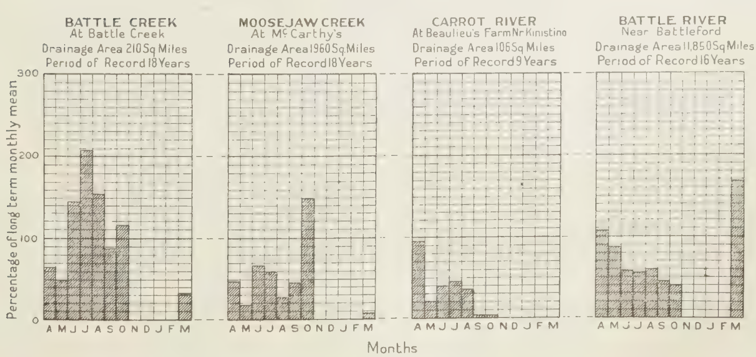


Plate 4

MEAN MONTHLY RUNOFF OF TYPICAL WATERSHEDS
IN
SASKATCHEWAN
FOR YEAR 1928-29
RUNOFF SHOWN AS PERCENTAGE OF LONG TERM MONTHLY MEAN



During the fiscal year some 2,158 discharge measurements were made and the mean yearly run-off for the district shows that streams of mountain source were above average while the flow from prairie streams was decidedly below normal.

Owing to the January thaw and general break-up conditions on prairie streams prior to March 31, 1928, a considerable share of the spring run-off was gone before April 1, resulting in subnormal run-off conditions on many streams for April. Rivers of mountain source on the other hand were a little above average in April but on account of low precipitation in May these as well as prairie streams dropped below their average flow.

Continuing into June and July splendid rains which were well distributed over both provinces, caused the run-off especially in the foothills, to be above normal.

From August, 1928, to March, 1929, inclusive, stream-flow in both provinces proved to be below normal with no exceptional conditions worthy of note during the period.

Unusually low precipitation during the fall of 1928 facilitated harvesting operations very much and also a light snow fall proved to be a feature of the ensuing winter. Temperatures ruled slightly above average for the year with rather a notable low spell during the last 10 days of January when 45 to 50 degrees below zero was a common minimum temperature. Ten stations distributed over the two provinces indicate a mean yearly temperature of 2 degrees above normal.

To present more in detail the above mentioned conditions the run-off month by month on four typical stations for each province is shown graphically on plates 3 and 4. In Alberta the representative stations are: the Belly river near Mountain View, the Elbow river at Calgary, the Clearwater river near Rocky Mountain House, and the Peace river at Peace River. In Saskatchewan they are: Battle creek at Battle Creek, Moosejaw creek at McCarthy's farm, Carrot river at Beaulieu's farm near Kinistino, and Battle river near Battleford.

In southern Alberta as typified by the Belly river the yearly run-off was 118 per cent of the long term mean and the precipitation was also above average. Flood discharges reached a maximum daily run-off of 16·86 second-feet per square mile in May as compared with 22·07 in June 1927, the highest on record. Minimum flow occurred in February and was at the rate of 0·28 second-foot per square mile as compared with 0·18 second-foot per square mile, the lowest in 16 years. (Worthy of note is a new monthly maximum discharge for April which was at the rate of 9·01 second-feet per square mile as compared with 6·99 the previous April record).

For central Alberta the typical stream selected was the Elbow river of which the run-off was 103 per cent of average. The yearly precipitation, however, as recorded at Calgary was somewhat below normal. Maximum run-off was at the rate of 7·60 second-feet per square mile in June which compares with 25·11 second-feet per square mile, the maximum for the period of record. Minimum discharge was at the rate of 0·08 second-foot per square mile in February and compares with 0·04 second-foot the minimum discharge recorded to date.

In north central Alberta as represented by the Clearwater river, both precipitation and run-off were above average, the latter of which was 122 per cent of the long term mean. A miximum daily discharge of 7·53 second-feet per square mile was recorded in June which compares with 32·21 the maximum for the past 14 years. Minimum flow occurred in January and was at the rate of 0·14 second-foot per square mile in comparison with 0·06 second-foot the lowest on record.

Typical of northern Alberta, the run-off for the Peace river was 91 per cent of the long term mean. Precipitation was also considerably below average. Maximum daily run-off was at the rate of 3·28 second-feet per square mile in June as compared with 5·20 second-feet per square-mile, the highest previously recorded. Low flow occurred in January and was at the rate of 0·12 second-foot per square mile as compared with 0·09 the lowest so far recorded.

The run-off in southeastern Saskatchewan as typified by Battle creek was 78 per cent of the mean for 18 years. The precipitation for the year was slightly below average although during June and July unusually steady rains were recorded. The maximum daily discharge occurred in June and was at the rate of 1·75 second-feet per square mile which compares with 7·95 the maximum previously recorded. Minimum run-off was at the rate of 0·06 second-foot per square mile in August and compares with nil discharge on several previous occasions.

Representing southeastern Saskatchewan, the seasonal run-off from Moose-jaw creek was only 42 per cent of the long term mean and the precipitation for the year was about 82 per cent of the average. Flood run-off was at the rate of 0·38 second-foot per square mile in April as compared with 1·53 second-feet the maximum run-off for previous years. Minimum flow was nil as on many former occasions.

In eastern central Saskatchewan the typical stream chosen was the Carrot river. Both run-off and precipitation for this area were below normal, the former of which was only 45 per cent of the long term mean. Flood discharges reached a daily maximum of 0·42 second-foot per square mile as compared with 4·30 second-feet, the highest heretofore recorded. Minimum flow was nil as on various previous occasions.

Representing west central Saskatchewan, the Battle river shows a run-off of 75 per cent of the average. Precipitation was also low varying probably from 5 to 10 per cent below average. Maximum run-off occurred in April and was at the rate of 0·18 second-foot per square mile as compared with 0·97 second-foot the highest on record. Minimum run-off for the area was at the rate of 0·01 second-foot per square mile which compares with nil on some former occasions.

Current Meter Rating Station

The only fully equipped current-meter rating station in Canada is operated by this organization at Calgary. The station has since its erection in 1911 been improved from time to time and is now undergoing extensive alterations which will bring it completely up to date. It will now be possible to carry out the work of calibrating current-meters and to make relative experiments for the improvement of stream measuring apparatus with great accuracy. At Calgary all metering instruments used by this Service and also by many private concerns, are rated. Instruments are first calibrated as received from the field so that recent measurements may be re-computed if necessary. After this rating the instrument is checked over and if necessary is repaired at the station workshop. It is then tested and re-rated before being returned to its user. During the fiscal year 1928-29 the station was in operation from May 3 to November 19. A total of 91 current-meters were rated, 186 ratings were made and 65 instruments were repaired in various degrees. Of the calibrations made, 3 were for the Water Rights Branch, B.C., 1 for the Department of Public Works, 1 for the Lethbridge Northern Irrigation District, 4 for the Canadian Pacific Railway Department of Natural Resources, and 1 for the Western Canadian Hydro Electric Corporation. The remainder were made for offices of the Service as follows: Ontario 21; British Columbia, 37; Quebec, 7; Alberta and Saskatchewan, 48; Nova Scotia and New Brunswick, 6; and Manitoba, 13.

Experimental work of considerable importance covering the design of new weights was carried out. A series of 44 experimental ratings was made. All experimental data are on file and can be supplied on demand. Requests for such information and advice *re* the use of various types of metering instruments have been called for from time to time. Description of the Current Meter Rating Station and details of numerous experiments have been furnished to the Hydro-Electric Department, Hobart, Tasmania.

Special Investigations

According to an arrangement in effect since 1921, the Calgary Power Company takes charge of the operation of storage in Lake Minnewanka reservoir during the emptying period, while the filling of the reservoir is in charge of this Service. Pursuant to this arrangement the supervision of operations at the dam at the outlet of the lake was assumed on May 2, 1927, by this Service and continued until October 1, when, as the tourist season in the Rocky Mountains Park was practically over and as the lake was at upper regulation level, the handling of the reservoir was turned over to the power company.

At the date of the taking over of the supervision of the reservoir for the filling season, an inspection trip was made to the dam in Devil's canyon by officials of this service and at the same time snow conditions in the Bow valley were investigated to aid in giving an estimate of the possible run-off. It was feared from knowledge of the amount of snow in the mountains that with heavy precipitation in June, floods might occur and caution was exercised in filling the reservoir until the danger period was passed when the water was brought to upper regulation level.

Owing to the mild fall and winter no ice jams occurred on the Cascade river this year and the reservoir was operated throughout without giving grounds for any complaint from property holders either at the reservoir or or along the river.

An application dated November 5, 1927, for licence to use and store the waters of the Bow river within the limits of the Ghost development was made to the Department by the Calgary Power Company. Preliminary approval of the above application was given by the Department conditional upon the receipt of a favourable report from the Commissioner of Irrigation. As the result of a very careful investigation made by the Commissioner of Irrigation, recommendation was made that the company's application receive favourable consideration. The Calgary Power Company upon receipt of the preliminary approval immediately proceeded to have made a very thorough geological examination of the dam and reservoir site, at the same time proceeding with the design of structures. Contract for the construction of the necessary works was let to the Foundation Company of Canada. This company was on the ground on June 11, 1928, and immediately proceeded with the assembling of the construction plant. Work was actually started on the dam in September and since then has been proceeding satisfactorily. Dr. T. H. Hogg, Chief Hydraulic Engineer of the Hydro-Electric Power Commission of Ontario, is acting as consulting engineer for the Department and Mr. B. Russell of this office is inspecting engineer and Dr. Hogg's representative on the ground. Weekly reports covering the progress of the work are submitted by Mr. Russell.

Information has been supplied regarding stream-flow and power sites in the province of Saskatchewan to the Saskatchewan Power Commission and others interested in the power problems of that province.

Several applications and requests for information regarding small power sites in Alberta and Saskatchewan have been received and information has been

supplied, but as the parties concerned have not taken any further action, no inspections have been necessary.

The use and demand for electric energy for light and power is continually increasing in the cities and towns of Alberta and Saskatchewan and, where it is economically possible, in the rural districts. This demand is causing growing interest in possible hydro-power developments in both provinces.

During 1928-29 the Calgary Power Company completed surveys for transmission lines north from the Ghost river to Edmonton and from Calgary to Edmonton. The line from Calgary to Edmonton carries a voltage of 13,500 and connects the smaller towns and cities between these two points with the Calgary Power Company's hydro system. Construction, it is anticipated, will start on the high voltage line between the Ghost river and Edmonton this spring. The company has also extended its transmission system by branches running east from the main lines. The company now has a transmission system covering a large portion of the province of Alberta and serves a large number of rural customers as well as the towns and cities. The market for power is rapidly growing in the province. Inspections of the proposed locations of transmission lines were made by officials of the Service during the summer of 1928 in order to investigate difficulties arising over the purchase of right of way.

The annual snow survey on the Upper St. Mary river in Glacier national park, Montana, was again carried out in May in co-operation with the district engineer of the Montana division of the United States Geological Survey. This completes the seventh consecutive year for this survey and the results are proving more useful each year in supplying data upon which the probable seasonal run-off for the St. Mary river may be estimated.

Carriage losses investigations on the Lethbridge Northern Irrigation District canal, which have been carried on since 1925, were continued in 1928. The first of these comprises a study of the losses between the canal intake and 2½ miles north of the Oldman flume. The second deals with losses in Keho Lake reservoir.

In the early spring of 1928 four of the eight joint international stations which were established in 1927, were equipped with continuous automatic stage recorders.

Steady rains in June and July again interfered with the Battle creek return flow investigation rendering it impossible to secure the desired results. Further attempts to carry out a portion of this study during 1929 will be made.

Stream-flow information was supplied on request for 138 stations during the year. Few flood warnings dispatches were necessary as no dangerous stream stages were recorded. Daily press information was, however, supplied during high water.

Hydrometric data secured by this Service were used in connection with operation by the eastern and western sections of the Canadian Pacific Railway Company's irrigation system, the Alberta Railway and Irrigation Company, the Lethbridge Northern Irrigation System, the Canada Land and Irrigation Company system, the New West Irrigation system, the Taber Irrigation system, and the Calgary Power Company.

DISTRICT OF MANITOBA

C. H. Attwood, District Chief Engineer

During the fiscal year ended March 31, 1929, the regular stream measurement and power investigatory operations of the Dominion Water Power and Reclamation Service in Manitoba and adjacent districts were continued.

The scope of the work covered by this district organization comprises the hydrometric, power, storage and reclamation investigatory work in Manitoba

and the Churchill River section of northeastern Saskatchewan, and also the hydrometric work in that portion of western Ontario and lying to the west of and including the Nipigon river.

Organization

The district organization of the Dominion Water Power and Reclamation Service, with headquarters in the Commercial Building, Winnipeg, was organized in 1912 and the work then instituted has been carried on and extended from time to time. The duties of the engineers and hydrometric recorders consist of both field and office work, covering surveys, investigations, inspection and supervision of construction and the preparation of the data collected in report form for submission to the head office.

Co-operation

The organization works in co-operation with several departments of the federal Government and with the Power Commission and Reclamation Service of the province of Manitoba. Co-operative arrangements with the Duluth district office of the United States War Department pertaining to the acquisition of flowage casements along the south shore of the lake of the Woods in Minnesota were continued. Arrangements are under way to co-operate with the United States Geological Survey in regard to the collection of stream-flow records on international streams along the boundary between the province of Manitoba and the states of Minnesota and North Dakota.

Hydrometric Survey

During the past year 114 regular and 27 miscellaneous stations have been maintained on lakes, rivers and tributaries in the following main watersheds: Nelson, lake Winnipeg, Winnipeg river, lake of the Woods, Rainy lake, and English, Red, Assiniboine, Dauphin and Saskatchewan rivers.

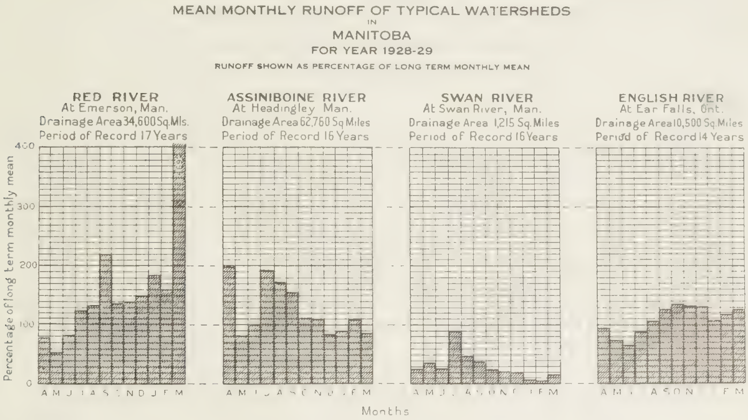
Of the above regular stations there were maintained for power and storage 62 all-year, 6 during open water and 6 miscellaneous stations; for drainage and reclamation throughout the year 7 regular, 30 during open water and 19 miscellaneous stations. Five regular all-year stations, together with 9 open water stations, were maintained for flood study. On international streams 13 all-year and 12 open water stations were maintained, together with 1 miscellaneous station. For water supply 4 regular stations were maintained during open water and for statistical purposes 5 all-year stations, while for meteorological purposes 11 stations were maintained continuously. In the above classification a number of stations have been maintained for more than one purpose.

With the exception of the northwestern section the average run-off throughout the district for the year was slightly above the mean for the period of record. Plate 5 shows in graphic form the run-off each month as a percentage of the long term monthly mean for four streams, each typical of a main diversion of the district.

In the northwestern portion of the district the records of the Swan river at Swan River, which is typical of the general run-off conditions of this district, show an average run-off for the year of 0·113 second-foot per square mile, or 37 per cent of the mean for the period of record. Low run-off conditions prevailed throughout the year, being particularly marked during the latter months. The flood run-off was quite low, being only 1·251 second-feet per square mile, or 18 per cent of the previous maximum. The minimum run-off for the year on the Swan river occurred in February, when no run-off was recorded, similar conditions having occurred in 1915.

In the southwestern and midwestern sections of the province the records of the Assiniboine river, which is typical of the general run-off conditions of this district, show an average run-off for the year of 0·042 second-foot per square mile, or 127 per cent of the mean for the period of record. The run-off conditions throughout this district, from month to month, corresponded fairly closely with the monthly records for the period of record. The flood run-off, occurring in April, was 0·202 second-foot per square mile, or 58 per cent of the maximum for the period of record. The minimum run-off for the year occurred in January and was 0·0046 second-foot per square mile, compared with a minimum of 0·001 for the period of record.

PLATE 5



For the southern portion of the province the records of the Red river, which is typical of the general run-off conditions of this district, show an average run-off for the year of 0·076 second-foot per square mile, or 103 per cent of the mean for the period of record. The run-off conditions throughout this portion of the province during the months of April, May and June were somewhat below normal, but throughout the remaining months conditions above normal were recorded. The flood run-off, occurring in April, was 0·486 second-foot per square mile, or 36·5 per cent of the maximum recorded in 1916. The minimum run-off for the year occurred in February and was 0·025 second-foot per square mile compared with a minimum of 0·003 second-foot for the period of record.

In the southeasterly portion of Manitoba and the extreme westerly section of Ontario, run-off as exemplified by the English river, was somewhat below normal during the months of April, May, June and July, but throughout the remaining months of the year the run-off was somewhat higher than the mean for the period of record. The average run-off for the year was 0·71 second-foot per square mile, or 107 per cent of the mean for the period of record. The maximum run-off for the year occurred in September, being 1·038 second-feet per square mile, compared with a maximum recorded run-off of 2·048 second-feet per square mile in July, 1927. Minimum run-off conditions occurred in April, when the run-off was 0·368 second-foot per square mile, or 125 per cent of the minimum for the period of record.

Flood conditions were not experienced on any of the main river systems in the district during the year. In July, following heavy rainfall in the southerly portion of the province, flood conditions were experienced along the Morris river and on some of the drainage ditches draining into this river.

Following heavy precipitation throughout the Lake of the Woods watershed in June, it was necessary to increase the outflow from the lake to a maximum

of 30,700 second-feet. Early in July the outflow was considerably lessened, and during the remainder of the year there was a gradual lowering of the lake level, regulation being carried out with the purpose of having ample storage capacity to provide for the usual increased inflow during the early summer months of 1929.

Special Investigations

LAKE OF THE WOODS FLOWAGE EASEMENTS

In carrying out the terms of Article 8 of the Convention and Protocol between Canada and the United States for regulating the Lake of the Woods, signed in July, 1925, the district engineer, United States Army Engineers, at Duluth, Minnesota, failed to obtain, by direct negotiation with the landowners, the required flowage easements on lands affected up to elevation 1064. Accordingly the United States Department of Justice, at the request of the War Department, instituted condemnation proceedings against those parcels of land over which the easement is required and these proceedings are now under way in accordance with the Minnesota State law. In September, 1928, a commission consisting of three citizens of the state of Minnesota was appointed by the senior judge of the United States Federal Court at Duluth and on October 1 this commission commenced a personal examination of each of the 267 claims contained in the first petition of the condemnation proceedings. This inspection was completed in November, but to date the commission has not announced its awards. A court hearing was held in Duluth in February, when arguments were presented before Judge Cant, senior judge of the United States Federal District, by attorneys representing the respondents and the Governments of the United States and Canada, covering the points of law involved to enable the court to give final instructions to the commissioners to guide them in making their awards. In March the commissioners inspected the hydro-electric plants on the Winnipeg river and hearings were held at Warroad on March 19 in order to permit the landowners to present arguments relative to land values in the district. The Dominion of Canada has been represented throughout these proceedings by counsel and by engineers of the Water Power and Reclamation Service.

Plans, outlining the protective measures for the village of Warroad as provided for in Article 8 of the Convention and Protocol have been prepared by the United States Army Engineers and received the approval of the International Lake of the Woods Control Board. The contract for the construction of the works has been awarded.

SEINE RIVER FLOOD PREVENTION PROJECT

For some years there has been agitation amongst the residents of the Seine river valley for relief from the damage caused by the periodical overflowing of the river, which not only results in the flooding of large areas of cultivated lands with consequent damage to or loss of crops but also entails considerable loss to property situated adjacent to the river in the urban and suburban areas of St. Boniface and St. Vital. As a result of representations made to the federal Government by the municipalities affected, it was arranged that an investigation be made of the situation to ascertain what areas were effected and to suggest what measures might be taken to alleviate the conditions.

During the year this investigation was carried out by this office, and the field surveys being confined to the area in which damage is sustained through actual over-flow from the Seine river. The report deals with the nature of the drainage basin, conditions that create flooding, lands affected, proposed methods for flood prevention and estimated costs of remedial measures.

ICELANDIC RIVER FLOOD PREVENTION PROJECT

The Icelandic river, flowing into lake Winnipeg, drains about 500 square miles in the interlake area between lake Winnipeg and lake Manitoba. The early settlers located along the lower reach of the river and soon became well established. However, in recent years fairly rapid settlement of lands along the upper reaches of the river has taken place, and many drainage ditches have been constructed. As a result of this agricultural development the run-off from the land, particularly following heavy precipitation, occurs much more rapidly and the lower lying lands and farms are subjected to flood, and the river, being of insufficient capacity to carry the rapid run-off, overflows and creates flood conditions along its course. Following representations as to the adverse conditions being experienced, arrangements were made for an investigation to ascertain what measures might be taken to improve the situation.

The investigation was carried out by this office during the year. The report is based on limited field surveys and valuable information received from the Reclamation Service of the province of Manitoba, and it outlines, with estimates of the cost, a scheme for flood prevention along the Icelandic river in the municipality of Bifrost.

LAC SEUL

Late in the summer several members of this staff were placed in charge of Mr. G. G. McEwan, who was engaged in making a survey based upon aerial photographs of the flooded areas at the eastern end of lac Seul. This survey was carried out in co-operation with the Ontario Government and the Lake of the Woods Control Board in connection with the development of the Lac Seul storage reservoir.

MANITOBA DAIRY FARMS LIMITED, WESTERN PROJECT

During the year an inspection was made of the new ditches constructed by the Manitoba Dairy Farms Limited through Townships 4 and 5, Range 9. These ditches were constructed in the fall of 1927 and have been functioning quite satisfactorily since that time. This inspection was made in company with the Chief Engineer of the Reclamation Service of Manitoba.

MANITOBA DAIRY FARMS LIMITED, EASTERN PROJECT

The application made in May, 1927, by the Manitoba Dairy Farms, Limited, of Marchand, Manitoba, to lease for reclamation by drainage for a period of 30 years the vacant and available Dominion lands situated in townships 1 to 11, ranges 9 to 17 E.P.M., with the option to purchase all or any part of the said lands at any time during the tenure of the lease upon satisfactory reclamation of the same being made, is still before the Department. As a result of the field surveys and investigations carried out during the winter of 1927-28 by officers of the Dominion Water Power and Reclamation Service, the Topographical Surveys Branch, and the Crown Timber Branch it has been possible to determine the nature of the land in this area, its feasibility of drainage, the timber resources and what interests, if any, would be affected by the proposed drainage and reclamation project. The Crown Timber Agent reports that this area contains considerable timber suitable for pulpwood, cordwood, saw-logs, railway-ties and fence-posts and that while the whole area is more or less forested with poplar, spruce and jack-pine, the greater portion of the merchantable timber is located throughout the area lying east of the Whitemouth river.

CO-OPERATION WITH DEPARTMENT OF INDIAN AFFAIRS

In August an extension was made to the sewerage system at the Sandy Bay Indian Residential School. This extension consisted of the construction of a cesspool to relieve the overburdened conditions in the existing septic tank.

In October this office was requested to prepare a report on the Water-Supply and sewage-Disposal systems for the Cecilia Jeffrey Indian School near Kenora. A report was prepared covering design, plans and estimates of the cost of construction, and the recommendations were approved by the Department of Indian Affairs. This work is now being carried out under the direction and supervision of this office.

In August an inspection was made of conditions above the power dam at McIntosh Indian School near McIntosh, Ont. Raising the level of the lakes above the dam has killed a certain amount of small timber along the borders of the lakes but the damage is very limited and no complaints have been made by interests directly concerned.

GREAT FALLS

An active construction program was carried out by the Manitoba Power Company during the year in connection with its hydro plant at Great Falls, this program of work being a continuation of the company's activities of the previous year. The work on the dam was confined to the rock-fill and earth embankment sections and was discontinued on October 12. About 16,000 linear feet of steel-sheet piling was driven through the earth-fill section of the dam with top elevation of the piling at 812. Some 13,000 linear feet of spruce piling was driven near the toe of the downstream face of the earth fill. Clay was then placed along both faces of this section of the dam. About 23,500 yards of crushed rock was placed along the upstream face of the rock-fill section between stations 0-00 and 4-00 and clay was then dumped along this face between stations 0-00 and 7-00. Work was not continued beyond station 7-00 inasmuch as the rock toe-wall has yet to be placed beyond this station. About 22,000 yards of rock was utilized in forming a rock wing wall back of the junction of the rock-fill and the earth embankment. A total of 152,000 yards of clay was placed on the dam during the year's operations.

During the year the installation of units Nos. 5 and 6 was commenced and completed. The installation of these two units completed the Great Falls plant, making the total installed turbine capacity 168,000 horse-power and the generator capacity 126,000-kv.a at 90 per cent power factor. Each unit consists of a 28,000-horsepower propeller type vertical turbine, direct connected to a 21,000 kv.a, 3-phase, 60-cycle, 11,000-volt, $138\frac{1}{2}$ r.p.m. vertical generator with direct connected exciter. Each generator is connected direct to the low tension side of a transformer bank consisting of three 7,000 kv.a. 11,000 to 66,000 volt delta or 11,000 to 110,000 star, oil insulated, water-cooled transformers. The plant is operated at 66,000 volts at the present time, but can be changed to 110,000 volts by changing the connection on the transformers from delta to star.

POINTE DU BOIS, EIGHT FOOT FALLS

The removal of the loosened rock and excavation necessary to bring the rock-cut to final grade and dimensions, with the necessary clearing up operations was continued during the present year and the cut was finally completed on September 30. The rock-cut as completed has a total width of 150 feet and is excavated to a floor elevation of 919 G.S. of C. datum. The work was commenced on July 4, 1927, and approximately 25,000 yards of rock were removed.

SLAVE FALLS

On November 23, 1928, the ratepayers of the city of Winnipeg authorized the expenditure of $6,500,000 for the development, by the city, of the Slave Falls power site. Anticipating a favourable vote by the ratepayers the city Council had authorized early in the year the clearing of the right-of-way for and the construction of a tramway from the Pointe du Bois power plant to the Slave Falls site. This work was started in February and was completed during the summer and put into operation. A transmission line was also authorized and completed to the site. In February work was commenced on the clearing of the campsite and the erection of temporary camp buildings. In October work was commenced on detailed surveys at the site, including the taking of soundings, borings and digging of test pits in order that all data necessary for designing the plant and estimating the cost thereof might be available. As this work is still in progress definite location of some of the sections of the proposed layout are undecided, but plans have been submitted showing the general layout, and detailed plans are being prepared. On November 26 contracts were awarded for the delivery and erection of two 12,000-horsepower turbines and two 500-horsepower turbines, also for two 10,000-kv.a generators and two 450-kv.a generators, this being the initial installation. Contracts have also been awarded for the delivery of round timber for cofferdam construction and of square timber for stop logs.

SEVEN SISTERS

On September 19, 1928, an interim licence was issued by the Department at the request of the Government of the province of Manitoba, to the Northwestern Power Company for the purpose of developing the Seven Sisters site on the Winnipeg river. Development work on the plant is now well under way, preliminary work having commenced early in 1928. The railroad from Whitemouth to the site has been completed and the transmission line from the Pinawa line to the Seven Sisters site, to supply power for construction purposes is now in operation. Permanent and temporary camps have been constructed, cofferdam construction is under way, and work is proceeding on the erection of a double track trestle bridge across the Winnipeg river at the site. The contract for the construction of the dam and power house has been awarded.

SNOW SURVEY

Late in February, at the request of the Lake of the Woods Control Board, a snow survey was made on the Lake of the Woods watershed. Data covering the depth of snow, water equivalent and special features were obtained at the following places: Warroad, and Winton in Minnesota, U.S.A., and at Fort Frances, Atikokan, and Kenora in Ontario. At these places fixed courses were referenced so that this survey may be made annually.

CHURCHILL RIVER

In March a member of this staff was sent to Island falls to obtain discharge measurements of the Churchill river and also to establish a regular metering section on the Churchill river near the Island Falls power site, so that regular discharge measurements may, in future, be obtained of the flow of this river.

WINNIPEG RIVER

In March gauges were established in the vicinity of Seven Sisters falls and a member of this staff was detailed to study backwater effects under winter conditions in the reach of the Winnipeg river immediately below Seven Sisters

falls. The river below these falls is wide and shallow, and the bottom strewn with boulders. Due to conditions in the river in this reach during the winter, the formation of ice causes considerable backwater, and a study of these conditions is necessary to forecast the effect of changed conditions of discharge following development and the diversion of the entire river flow to this reach and provide for the necessary remedial measures to prevent undue loss of head by backwater caused by ice conditions.

DISTRICT OF ONTARIO

N. Marr, District Chief Engineer

ORGANIZATION

During the fiscal year ending March 31, 1929, the regular stream measurement and power investigatory work of the Dominion Water Power and Reclamation Service of the province of Ontario has been carried on.

This was done in accordance with the terms of a co-operative agreement between the Department of the Interior and the Hydro-Electric Power Commission of Ontario.

The work of the Ontario Hydrometric Survey was carried on under the supervision of the district chief engineer with head office in Ottawa. The greater part of the field work was done by a field staff with an office at North Bay, while certain stations in the eastern part of the province and fifteen stations on streams tributary to the Ottawa river in the province of Quebec were, for reasons of economy and convenience, handled from the head office at Ottawa. The hydrometric investigations in that part of the province west of and including, the Nipigon river were, as in previous years, under the direction of the district office in Winnipeg.

CO-OPERATION

In pursuing the field and office investigations the closest co-operation has been maintained with the officers of the Hydro-Electric Power Commission of Ontario. Particular reference should also be made to the following corporations which have given the engineers of the district valuable assistance and information: The Abitibi Power and Paper Company; the International Nickel Company of Canada; the Kaministiquia Power Company; the Mattagami Pulp and Paper Company; the Mississippi River Improvement Company; the Pigeon River Lumber Company; the Spanish River Pulp and Paper Company; the Spruce Falls Company; the Northern Ontario Power Company, and the Gatineau Power Company.

HYDROMETRIC SURVEY

During the fiscal year ending March 31, 1929, 62 regular stations were maintained on rivers and tributaries in the following watersheds: Hudson bay, lake Superior, lake Huron, lake St. Clair, lake Erie, lake Ontario, and Ottawa river.

Of these, 56 were maintained throughout the year for power purposes, 5 were maintained throughout the year for flood study, and one on an international power control problem.

For the purpose of illustrating the run-off conditions throughout the province, the mean monthly discharge of four typical streams have been computed in terms of the mean for the period of record. This variation month by month is shown by the attached graph. *(See Plate 6.)*

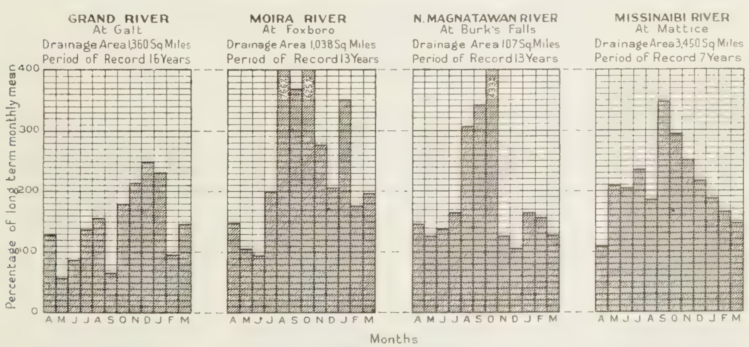
The stations selected are the Grand river at Galt, the Moira river at Foxboro, the North Maganatawan river at Burks Falls and the Missinaibi river at Mattice. In the southwestern portion of the province as typified by the Grand river, precipitation was above normal, the run-off being 142 per cent of the long term mean. Flood run-off reached a maximum daily discharge in March of 17·30 second-feet per square mile of drainage area, as compared with 22·125 second-feet per square mile, the maximum for the period of record. The low run-off which occurred in September was at the rate of 0·078 second-foot per square mile as compared with 0·036 second-foot per square mile, the lowest so far recorded.

For the eastern portion of the province the stream selected is the Moira river at Foxboro. The precipitation was much above normal, the run-off for the year being 193 per cent of the long term mean. Flood run-off reached a maximum daily discharge of 10·52 second-feet per square mile in April as compared with 12·003 second-feet per square mile, the maximum for the period of record. The low run-off which occurred in September was at the rate of 0·348 second-foot per square mile as compared with 0·014, the minimum discharge so far recorded.

In the North Bay district the typical stream selected is the North Maganatawan river at Burks Falls. The precipitation was above normal and the run-off for the year was 167 per cent of the long term mean. Flood run-off in April reached a maximum daily discharge of 31·90 second-feet per square mile. This is the highest daily discharge on record. The low run-off which occurred in September was at the rate of 1·100 second-feet per square mile as compared with 0·008, the minimum discharge so far recorded.

PLATE 6

MEAN MONTHLY RUNOFF OF TYPICAL WATERSHEDS
IN
ONTARIO
FOR YEAR 1928-29
RUNOFF SHOWN AS PERCENTAGE OF LONG TERM MONTHLY MEAN



For the northern portion of the province the typical stream selected is the Missinaibi river at Mattice. The precipitation was above normal and the run-off for the year was 200 per cent of the long term mean. Flood run-off in May reached a maximum daily discharge of 14·60 second-feet per square mile. This is the highest on record. The low run-off which occurred in March was 0·186 second-foot per square mile as compared with 0·047 second-foot per square mile, the lowest daily discharge on record.

SPECIAL INVESTIGATIONS

During the year the analysis of the water and storage resources of Ontario was continued in close co-operation with the provincial authorities. In 1925 a list of water-powers of Ontario was prepared by the Dominion Water Power

and Reclamation Service, co-operatively with the Director of Surveys and Chief Engineer of the Ontario Department of Lands and Forests, and the list was published by that department. Since the publication of the 1925 list, numerous rivers, particularly in the northern and western parts of the province, have been investigated in considerable detail by the provincial authorities and the information thus secured, together with the later records of stream-flow secured by the Dominion Hydrometric Survey, warrants the re-analysis of the power resources on many streams. Accordingly, towards the end of the fiscal year this information was being systematically collated with the object of preparing a revised list for publication, possibly in 1930.

On the Niagara river special studies were continued of river slopes, of the effect of diversion in governing pool levels, and of the discharge of the river referred to the Buffalo break-water gauge. These studies were carried out in close co-operation with the investigations made by the Special International Niagara Board appointed to report to the Governments of Canada and the United States upon the matter of the preservation of the scenic beauty of Niagara falls. The special board submitted an interim report to the two Governments on December 14, 1927, making certain suggestions and recommendations with respect to remedial works and after reviewing the board's report, the two Governments agreed to the recommendations and embodied the agreement in the Niagara Convention and Protocol signed at Ottawa, January 2, 1929, which only awaits ratification by the respective federal authorities in the two countries before being put into effect. The basic investigatory work on the Canadian side in connection with the board's studies was all carried out by the Ontario staff of the Dominion Hydrometric Survey.

On the St. Mary river at Sault Ste. Marie officers of the Ontario staff afforded further assistance to the International Lake Superior Control Board in the re-calibration of the discharge through the dam controlling the level of lake Superior.

DISTRICT OF QUEBEC

L. G. Denis, District Chief Engineer

Work was continued by the Dominion Water Power and Reclamation Service in Quebec province on basic water-power investigations and related matters during the year in conformity with the co-operative agreement between the Department of the Interior and the Quebec Streams Commission. This work comprises the maintenance and operation of a number of hydrometric stations throughout the province established to supply reliable data as a sound basis for the intelligent development and utilization of Quebec's vast water-power resources.

Organization

The Quebec work is under the district chief engineer whose office is at 961 Inspector Street, Montreal, close co-operation being maintained with the Quebec Streams Commission whose head office is located in the same city.

Co-Operation

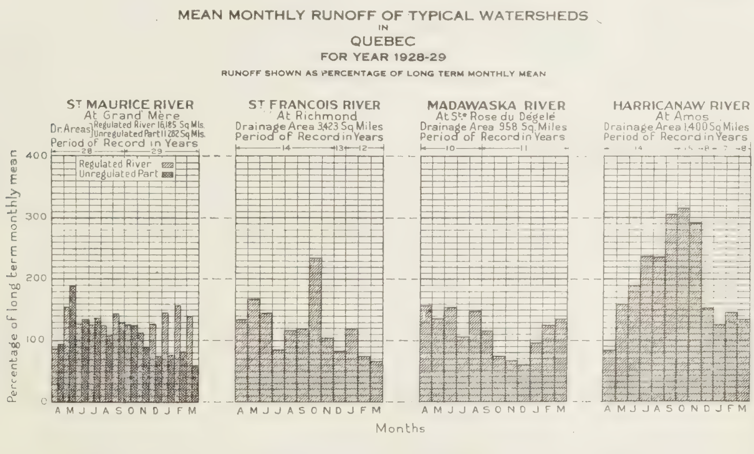
The investigations are carried on along definite lines in a well balanced co-operation with the Quebec Streams Commission. In addition to this, many large corporations and private organizations interested in the information secured afford a full measure of co-operation with the service in many of its activities. Among these organizations may be mentioned the Shawinigan Water and Power Company; Duke-Price Power Company; Canadian Hydro-Electric Corporation Limited (Gatineau Power Company); Power Corporation of

Canada, Limited (Southern Canada Power Company); Price Brothers and Company Limited; Quebec Power Company; Ontario Power Company; Lower St. Lawrence Power Company.

Hydrometric Survey

During the fiscal year ending March 31, 1929, 92 gauging stations were maintained on rivers and lakes in the following main watersheds: Ottawa, St. Maurice, St. Francois, Saguenay, other northern and southern tributaries of the Middle and Lower St. Lawrence, Nottaway, and Harricana rivers. Of these 73 are all-year discharge record stations, one is operated for discharge records during the open season only, and 18 operated all year for the observation of water levels only. Of the total, 8 are for storage regulation, 76 others are maintained for power, and 8 for both flood and power studies. In addition to these, miscellaneous measurements were obtained at 15 other points. The comparatively late winter was followed by a rather late spring in 1928, marked by heavy rain, and sudden rise in temperature resulted in above normal run-offs and caused serious floods in certain sections; abundant rain also caused summer run-offs to rise well above normal in various parts of the province and exceedingly so in the northern portion; the autumn precipitation varied considerably in different sections of the province, the run-off remaining high in the north and from slightly above normal to below normal in other parts. The erratic, but on the whole rather mild winter of 1928-29, at first gave slightly subnormal run-offs in certain sections followed by general conditions well above normal. During the fiscal year the temperature was slightly above the previous average recorded and a comparison drawn from 7 representative meteorological stations distributed over the province shows a mean yearly temperature for the year nearly half a degree Fahrenheit above the corresponding average of previous years.

Plate 7



For the purpose of illustrating the general run-off conditions in Quebec, graphs showing the variation from the mean, month by month, for four typical stations have been prepared and are attached. (*See Plate 7.*) The stations selected for this province are at Grand'Mère for the St. Maurice river, Richmond for the St. Francois river, Ste. Rose-Dégelé for the Madawaska river and Amos for the Harricana river.

On the north side of the middle St. Lawrence, as typified by the St. Maurice river, precipitation was above normal and the run-off for the year was 131 per cent of the long term mean. Flood run-off reached a maximum daily discharge

of 9·9 second-feet per square mile in May as compared with 10·7 second-feet per square mile, the maximum for the period of record. The low run-off which occurred in December was at the rate of 0·9 second-foot per square mile as compared with 0·20 second-foot per square mile, the lowest so far recorded.

For the southern portion of the province, the typical stream selected is the St. Francois river. The precipitation was slightly above the average and the run-off 138 per cent of the long term mean. Flood run-off reached a maximum daily discharge of 17·1 second-feet per square mile in April as compared with 18·1 second-feet per square mile, the maximum for the period of record. The low run-off which occurred in September was at the rate of 0·46 second-foot per square mile as compared with 0·22 second-foot per square mile, the lowest so far recorded.

For the eastern portion of the province, south of the St. Lawrence, the typical stream selected is the Madawaska river. The precipitation was above the average and the run-off for the year 121 per cent of the long term mean. Flood run-off reached a maximum daily discharge of 11·5 second-feet per square mile in May which was the highest maximum for the period of record. The low run-off which occurred in April was at the rate of 0·42 second-foot per square mile as compared with 0·05 second-foot per square mile, the lowest so far recorded.

For the northern portion of the province, the typical stream selected is the Harricana river. The precipitation was well above normal and the run-off for the year was 197 per cent of the long term mean. Flood run-off reached a maximum daily discharge of 7·1 second-feet per square mile in May which was the highest maximum for the period of record. The low run-off which occurred in April was at the rate of approximately 0·53 second-foot per square mile as compared with 0·14 second-foot per square mile, the lowest so far recorded.

Special Investigations

Throughout the year special attention was given to securing from various public and private sources all possible additional up-to-date information on developed and undeveloped water-power of the province; this information was classified and in some cases summarized for ready reference. All-surveyed or explored rivers of the province are now fairly well covered and it is possible to supply available reliable data in answer to numerous requests for information in connection with preliminary studies of power development and industrial expansion. This material also forms part of the basis of the Water Power Resources Inventory, and is used in the preparation of power river synopses. Efforts were also made to secure further available data in respect to the levels of lake Memphremagog and the outflow therefrom in connection with international problems.

The exhaustive list of Quebec water-powers compiled by this service in co-operation with the Hydraulic Service of the Quebec Department of Lands and Forests and the Quebec Streams Commission was finally revised, brought up-to-date, and published for public distribution by the latter commission.

DISTRICT OF THE MARITIME PROVINCES

K. G. Chisholm, District Chief Engineer

The hydrometric and power investigatory operations of the Dominion Water Power and Reclamation Service were continued throughout the Maritime Provinces during the fiscal year ending March 31, 1929, in accordance with the co-operative agreements of 1919 between the Minister of the Interior on behalf of the federal Government and the Governments of Nova Scotia, New Brunswick, and Prince Edward Island.

ORGANIZATION

Office accommodation is provided by the Nova Scotia Power Commission, and the district office is situated at Halifax, which is centrally located and provides convenient accessibility to all parts of the Maritime provinces.

The primary duty of the organization is the acquirement of stream-flow data which is compiled, analyzed and finally published in a form suitable for use in studies of water supply and power and other allied purposes. Simultaneously with this statistical work, power and storage surveys and investigations are carried on also. At the same time members of the staff are available for consultation and co-operation in water-power projects as they arise. The files of the Service have become the chief source of reference for water-power data in the Maritime Provinces and are becoming more valuable year by year as further data accumulate. These files are kept in constant use in answering inquiries from the public.

CO-OPERATION

In the course of the work the closest co-operation is maintained with the Nova Scotia Power Commission and the New Brunswick Electric Commission and all other persons and corporations interested in stream-flow and power data. Preliminary surveys and investigations of the Service have been used as the basic data in most of the developments that have taken place and requests for further co-operative studies are constantly being received from municipalities, corporations and private promoters.

HYDROMETRIC SURVEYS

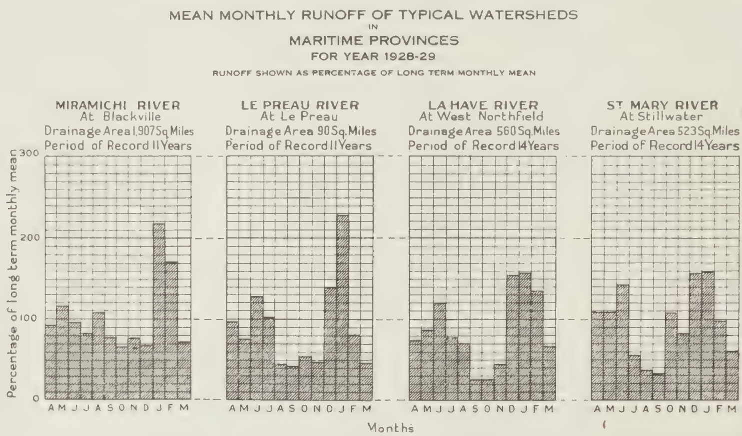
Thirty-four regular gauging stations were operated during the year; 21 in Nova Scotia, 10 in New Brunswick and 3 in Prince Edward Island. Nearly all these stations produce records of first class accuracy and many of them have been maintained continuously since the work of the Dominion Water Power and Reclamation Service was extended into this district in 1915. With few exceptions the gauging stations are on important power streams. The records obtained are applicable not only to the streams under observation, but also to others in adjoining territory and the stations are situated so that run-off data is available, either directly or by comparative methods, for all portions of the districts. In Prince Edward Island, owing to poor control and excessive variation from the operation of numerous mills, hydrometric work is carried on under difficulties. Gauging stations are maintained, however, on three representative streams from which records are obtained that give a very fair indication of the run-off characteristics of the island.

In Nova Scotia one new station was established during the year. This is on Herring Cove brook from which the Mersey Pulp and Paper Company will obtain its water-supply for mill purposes at the new pulp and paper mill at Brooklyn. Run-off records were urgently requested by the company who co-operated in the installation of the station to the extent of constructing the artificial control necessary in order that records of sufficient accuracy might be obtained. The station at Scotsville at the outlet of lake Ainslee, installed in January, 1927, at the request of the Nova Scotia Power Commission for the purpose of comparing the actual outflow of the lake with that recorded at the regular station of the service two miles down stream, was abandoned in January, 1929, as one year's records had been obtained and sufficient data secured for comparative purposes. In New Brunswick the station on the Peticodiac river, operated for the New Brunswick Electric Power Commission, was discontinued at the beginning of the winter season but will be maintained during

low water periods as it is the minimum flow that is of interest to the commission who wish to decide on the sufficiency or otherwise of a supply of condensing water for a steam plant which they propose to construct in the vicinity of Salisbury.

With the marked increase in water-power construction that has taken place in Nova Scotia during the past few years, a number of important power streams are rapidly becoming developed. Power investigations and run-off records of the Dominion Water Power and Reclamation Service have supplied the basic data on which the original estimates of power output and cost, and the economics of development, have depended. The construction of these new plants has, however, interfered with the operation of several gauging stations and as the process continues there will be a greater demand for automatic gauging equipment in order that satisfactory records may be obtained. In some cases it may be possible to obtain run-off data from the operating records of the various plants and this problem is receiving careful attention.

PLATE 8



The mean run-off for the year was on the whole not far from normal. In general, although the seasonal variation differed somewhat throughout the district, the summer and fall months from July to November, were unusually low, and the winter months, December to February, unusually high. No record droughts or floods occurred. The low water of the summer and fall was not as severe as in some past years such as 1921 in Nova Scotia and 1922 in New Brunswick, while the mean for the super-normal winter months was nowhere as great as the average for the spring freshet months.

For the purpose of illustrating the run-off conditions, graphs showing the variation from the mean, month by month, for two typical stations in each province are given on Plate 8.

On the LaHave river, which is typical of streams in the southwestern part of Nova Scotia, the run-off was 93 per cent of the average flow during the past fourteen years. The highest daily discharge of 4,170 second-feet, equivalent to 8·4 second-feet per square mile, occurred on January 20, as compared with an absolute maximum of 36·4 second-feet per square mile in 1926. The minimum for the year occurred in September and was at the rate of 0·13 second-foot per square mile, which is four times as great as the lowest water in the drought year of 1921.

The run-off of the St. Mary river in eastern Nova Scotia was 103 per cent of the long term average. The greatest daily discharge of the year, equivalent

to 27·7 second-feet per square mile, occurred on December 11 and the lowest daily discharge of 0·12 second-foot per square mile occurred in September. An absolute maximum of 41·0 second-feet per square mile, and an absolute minimum of 0·04 second-foot per square mile have been recorded on this river since 1915.

In the southern part of New Brunswick the run-off on the Lepreau river was 94 per cent of the long term average. The miximum daily run-off occurred on January 7 and was at an estimated rate of 23·3 second-feet per square mile, as compared with 167 second-feet per square mile in the flood of April 30, 1923. The lowest run-off for the year of 0·20 second-foot occurred in September. The minimum discharge in the whole period of record occurred in 1921, and was equivalent to 0·03 second-foot per square mile.

In northern New Brunswick, as typified by the Miramichi river, the run-off was 100 per cent of the long term mean. The maximum daily discharge occurred on May 4 and was at the rate of 17·4 second-feet per square mile, which was only one-third of the maximum. The lowest run-off occurred in September and was at the rate of 0·48 second-foot per square mile, as compared with 0·17 second-foot per square mile in 1923.

SPECIAL INVESTIGATIONS

A considerable amount of special investigatory work was accomplished during the fiscal year. Much of it was undertaken at the urgent request of the Nova Scotia Power Commission whose engineering staff was so fully occupied with power development on the Mersey and Tusket rivers that they were forced to ask for assistance from the service. Survey parties were in the field from early in April until the middle of November with only such breaks as were required by hydrometric and other work which could not be postponed.

The most important investigation dealt with a proposed increase in the supply of hydro-electric power for the city of Halifax. A diversion of the Ingram river through the St. Margaret Bay system was surveyed in full detail and plans and estimates worked out which showed that a further supply of sixteen million kilowatt hours could be supplied to Halifax at a delivered cost of 0·68 cent per kilowatt hour. To meet further increases in the Halifax demand investigations were also completed of the Sackville river and of the North East river between Wrights lake and Pockwock lake. The plans and estimates of these surveys have not yet been completed.

Power and storage investigation of the Herbert river, which was begun during 1927, was finally completed early in November, 1928. The office work connected with this investigation still remains to be completed.

Early in April a special investigation at the request of the Minister under the *Nova Scotia Water Act* was performed. This investigation dealt with a dispute between lumber and power interests on the Medway river and required an examination and report on certain log sluices and dams and the superintendence of a drive of logs from above Eel lake to a point near South Brookfield.

Considerable assistance was given to the Avon River Power Company in the construction of their small plant on Fall river which is now complete and is supplying 40 miles of territory between Waverley and Brookfield. Certain matters of pipe line location, surge tank design and recommendations as to storage development, were submitted to the company at its special request.

In November an inspection of the international section of the St. Croix river was completed for Mr. J. T. Johnston, the Canadian member of the International St. Croix River Board of Control.

Two power investigations were carried out in Prince Edward Island. One of these comprised the survey of a site on the Midgell river at the request of a committee representing St. Peters, Morell and surrounding districts, and included

an investigation of the territory proposed to be served so that the construction of transmission and distribution lines could be properly estimated upon; plant capacity and layout determined and cost estimates prepared. A report was submitted to the communities interested on June 21. The other investigation in Prince Edward Island was made for the Hunter River Electric Light Company Limited. Field work connected with this investigation was completed on August 15 and shortly thereafter a report was submitted in which the findings of the investigation were presented in some detail.

An inspection of a parcel of land at Shelburne was made for the Acting Director, Ordnance, Admiralty and Public Lands Division, Department of the Interior.

In January, 1929, a brief investigation was made of a small stream in Cape Breton near the village of Judique as a possible source of light and power supply for that community, and in February a similar investigation was made of Gillis brook near Coxheath, Cape Breton, for people in Sydney; by request transmitted through members of the Nova Scotia Government. Following both of these investigations the enquirers were advised that development of the proposed sites was not considered economically feasible.

Many inquiries were received from various sources for run-off records and power data.

PART III

RECLAMATION

IRRIGATION

J. S. Tempest, Commissioner of Irrigation

During the early part of the year 1928 weather conditions throughout the irrigation districts were adverse owing to lack of moisture, and high winds which caused soil drifting and an unsatisfactory condition for seeding and crop germination. Commencing with the first week in June precipitation became more general and as a result, from this period until harvest very little water was used for irrigation. Low temperatures and early frosts during the latter part of the season were not favourable to maturing crops and lowered the grade of all grains. However, harvesting conditions were ideal and in great contrast to the preceding year.

In the early part of the season many requests for advice and assistance in laying out farm ditches were received from the various irrigation districts. Our officers were able to comply with these requests but, although much field work was done, very little actual construction was undertaken owing to the generous rainfall which set in early in June. In addition to this phase of the work an officer of the Department has been engaged continuously in bringing before irrigation farmers, in practical form, the results of the research work undertaken over a period of eleven years at the Brooks Duty of Water Experimental Station.

In the last annual report attention was directed to the investigation of problems affecting the water requirements of crop and the rise of the water-table due to continued application of irrigation water. Soil moisture tests and the study of conditions in the root-feeding zones of crops were continued.

Investigation of seepage and alkali problems and classification of irrigable lands in various irrigation districts was continued throughout the season.

Duty of water experiments at the Brooks Station were continued and data covering the past eleven years are being co-ordinated and compiled.

Field investigations were made during the season of the development of the root system and the seasonal use of water by sugar beets. More detailed information concerning these investigations will be found in this report.

Water Administration

During the calendar year 1928, 72 applications were filed for the appropriation of water under the Irrigation Act, together with 603 applications by the provinces of Alberta and Saskatchewan for the use of lakes and other bodies of water for fur farming purposes; 30 water licences were issued and 176 special forms of licences for fur farming.

At the end of the year there were in good standing 1,070 water licences, 186 fur farming licences, 22 temporary permits, 245 authorizations and 257 projects under investigation in addition to 578 fur farming applications.

Evaporation.—Further progress has been made in the collation and compilation of evaporation data and preliminary maps have been prepared showing the normal distribution of evaporation in the two provinces. The evaporation from lakes and reservoirs in relation to experimental results from pans of

various types has been studied in detail and these investigations suggest that over long periods the summation of results for the Alberta and Saskatchewan Standard pan do not differ very materially from the figures computed from reservoir data, but there are large differences in monthly comparison, probably due to the effect of heat storage in deep bodies of water as compared with small pans. The effect of wind-breaks and similar obstructions to wind velocity has an important bearing on evaporation.

Crop Results.—While moisture and evaporation appear to be the main factors in crop production the fertility or organic content of the soil is an important contributor. These values are, in turn, affected by the natural growth over long periods, so that there is a cumulative effect from favourable climatic conditions. The purpose of irrigation is to obtain a correct adjustment by the addition of moisture to balance evaporation and transpiration.

Two important by-products of correct irrigation are:

(1) the building up of organic matter in the soil, and
(2) the reduction of evaporation by tree growth.

Both these conditions tend to reduce the water requirement for efficient crop growth and the storage of soil moisture is more constant where water is applied at regular intervals.

Drainage.—Hydrological data collected primarily in connection with water-supply problems can be applied with advantage to the study of drainage requirements. In this case the need is to remove surplus water as run-off in order that the land may be sufficiently dry for healthy plant growth and for agricultural operations.

Inspection Work

A staff of eleven engineers, each in charge of a district, carried out field work consisting of inspections in connection with the administration of the Irrigation Act and collection of hydrometric data on streams and canals. The following is a summary of work in each district:—

District	Gauging stations	Inspections	Surveys	Gaugings
South Saskatchewan	12	40	8	86
North Saskatchewan	12	22	.....	80
Boundary	72	41	7	597
Medicine Hat	37	56	12	170
Calgary	13	23	4	118
Lethbridge and Vauxhall	14	30	1	125
Cardston	38	19	4	403
Macleod	13	30	7	157
Banff	26	5	2	195
Edmonton	14	28	6	95
North Alberta	18	60	9	132
Totals	269	354	60	2,158

Very little irrigation was practiced, although water could have been applied to great advantage during the month of May when precipitation was very low, and in many localities, insufficient to germinate the seed. After the first week of June there was ample rainfall for crop growth in practically all parts of the two provinces. Inspection work during the season presented no unusual features and requires no special comment.

Watermasters.—Six watermaster warrants were again in force this year. They covered the six inspection districts adjacent to the international boundary in the two provinces, viz: Macleod, Cardston, Lethbridge and Medicine Hat districts in Alberta; Boundary and south Saskatchewan districts in Saskatchewan.

Domestic Water Supplies.—Ready access to a convenient water-supply for domestic and stock-watering purposes is essential to the farmer and rancher. To those resident in districts where perennial streams exist this does not present any problem, but in areas where stream-flow is periodic the settler is faced with the necessity of conserving a water-supply to carry him over the non-flow periods. There are many artificially created domestic water-supplies in the semi-arid regions of southern Alberta and southern Saskatchewan and in portions of the Peace River district.

A common method followed in the construction of domestic reservoirs is to throw an earthen embankment across a suitable draw, coulée or other watercourse and excavate a spillway ditch around it to take care of surplus water. A dugout in the channel of the watercourse is another means used to create domestic storage. Both methods are effective and, other than the labour of the settler, require no outlay—an important consideration in a new country.

Many artificial water supplies have been legalized but there are known to be a large number which are as yet unauthorized. With increased settlement water-supply conditions are necessarily becoming more acute and the advisability of legalizing these unauthorized domestic supplies is growing more and more important from the owners' standpoint as well as from that of the Department. This is pointed out by our inspecting engineers when opportunity occurs and their experience and assistance is placed at the disposal of the settlers in designing and improving water supplies and in submitting applications.

Municipal Water Consumption Data

These data have been collected for a number of years and the records compiled therefrom are submitted in the tables appended. The Department is indebted to the various towns and cities for their co-operation in furnishing the monthly records.

Cities and Towns in the Province of Alberta

Record of Daily Water Consumption in Imperial Gallons for the Year 1928

Athabaska—Population 450

Month	Daily Average for the month	Per Head for domestic purposes	Per Head for industrial purposes	Per Head for other purposes	Per Head for all purposes	Unaccounted for
January	7,032	15·6			15·6	
February	7,414	16·5			16·5	
March						
April						
May		No Records				
June						
July						
August						
September	5,250	11·7			11·7	
October	4,621	10·3			10·3	
November	4,900	10·9			10·9	
December	4,935	11·0			11·0	
Average for the year	*5,692	12·6			12·6	

Bassano—Population 1,000

Month	Daily Average for the month	Per Head for domestic purposes	Per Head for industrial purposes	Per Head for other purposes	Per Head for all purposes	Unaccounted for
January	169,355				169·4	
February	160,862				160·9	
March	126,452				126·5	
April	175,333				175·3	
May	200,000				200·0	
June	187,500				187·5	
July	165,484				165·5	
August	199,839				199·8	
September	216,333				216·3	
October	201,452				201·5	
November	179,167				179·2	
December	175,484				175·5	
Average for the year	179,772				179·8	

Edmonton—Population 65,000

Month	Daily Average for the month	Per Head for domestic purposes	Per Head for industrial purposes	Per Head for other purposes	Per Head for all purposes	Unaccounted for
January	6,379,677	56·9	24·5	16·7	98·1	
February	6,364,138	56·8	24·5	16·6	97·9	
March	6,246,774	55·8	24·0	16·3	96·1	
April	6,217,667	55·5	23·9	16·3	95·7	
May	6,700,323	53·8	25·8	17·5	103·1	
June	6,583,000	58·7	25·4	17·2	101·3	
July	7,092,903	63·3	27·3	18·5	109·1	
August	6,836,774	61·0	26·3	17·9	105·2	
September	6,604,333	58·9	25·4	17·3	101·6	
October	6,595,161	58·9	25·4	17·2	101·5	
November	6,927,667	61·8	26·7	18·1	106·6	
December	6,789,355	60·6	26·1	17·8	104·5	
Average for the year	6,611,481	59·0	25·4	17·3	101·7	

Lethbridge—Population 12,000

Month	Daily Average for the month	Per Head for domestic purposes	Per Head for industrial purposes	Per Head for other purposes	Per Head for all purposes	Unaccounted for
January	1,276,903	69,7	36·7		106·4	
February	1,268,655	68·6	37·1		105·7	
March	1,283,258	67·7	39·2	0·1	107·0	
April	1,315,400	69·6	39·9	0·1	109·6	
May	1,791,424	105·4	40·0	3·9	149·3	
June	1,540,500	84·7	42·5	1·2	128·4	
July	1,572,290	83·7	46·4	0·9	131·0	
August	1,828,181	99·5	48·3	4·5	152·3	
September	1,526,167	82·0	43·9	1·3	127·2	
October	1,486,677	82·0	41·7	0·2	123·9	
November	1,497,700	77·7	47·1		124·8	
December	1,405,774	72·8	44·3		117·1	
Average for the year	1,482,747	80·3	42·3	1·0	123·6	

Medicine Hat—Population 10,000

Month	Daily Average for the month	Per Head for domestic purposes	Per Head for industrial purposes	Per Head for other purposes	Per Head for all purposes	Unaccounted for
January	2,234,516				223·4	
February	2,176,552				217·7	
March	2,182,258				218·2	
April	2,235,333				223·5	
May	3,550,645				355·1	
June	3,101,333				310·1	
July	3,293,871				329·4	
August	3,533,226				353·3	
September	3,225,667				322·6	
October	2,697,742				269·8	
November	2,718,000				271·8	
December	2,632,581				263·3	
Average for the year	2,798,477				279·8	

Redcliff—Population 1,100

Month	Daily Average for the month	Per Head for domestic purposes	Per Head for industrial purposes	Per Head for other purposes	Per Head for all purposes	Unaccounted for
January	136,573				124·2	
February	121,172				110·1	
March	152,516				138·6	
April	151,483				137·7	
May	251,411				228·6	
June	222,058				201·9	
July	239,96[illegible]				218·1	
August	204,306				185·7	
September	153,000				139·1	
October	175,806				159·8	
November	143,750				130·7	
December	127,500				115·9	
Average for the year	173,295				157·5	

Average for 6 months.

Record of Average Daily Water Consumption in Imperial Gallons for Years 1915-1928 (Inclusive)

Average for Year	Per Head Domestic	Per Head Industrial	Per Head other purposes	Per Head all purposes	Unaccounted for	Per Head Domestic	Per Head Industrial	Per Head other purposes	Per Head all purposes	Unaccounted for
	Edmonton					Lethbridge				
1915	46·0	31·0	3·0	80·0	...	81·4	32·2	1·5	115·1	...
1916	52·5	20·7	5·7	78·9	...	116·0	41·3	0·7	158·0	...
1917	56·3	25·0	9·7	91·0	...	95·0	55·0	...	150·0	...
1918	58·0	26·2	10·1	94·3	...	102·2	44·7	3·0	149·9	...
1919	56·7	24·6	9·7	91·7	...	78·1	26·9	...	107·3	...
1920	54·7	23·4	16·2	94·3	...	91·8	35·1	6·8*	129·1	...
1921	54·6	23·4	16·8	94·8	...	94·2	27·8	1·4	123·4	...
1922	62·2	24·9	24·1	111·1	...	110·8	33·5	...	145·1	...
1923	53·5	22·4	13·5	89·4	...	96·0	35·4	0·7	132·1	...
1924	55·0	23·7	15·7	94·4	...	88·8	36·8	0·4	127·0	...
1925	54·1	23·3	15·8	93·2	...	74·7	35·0	0·8	110·5	...
1926	54·0	23·2	15·8	93·0	...	76·6	36·8	1·5	114·9	...
1927	55·1	23·8	16·1	95·0	...	71·0	36·2	0·6	107·8	...
1928	59·0	25·4	17·3	101·7	...	80·3	42·3	1·0	123·6	...
	Bassano					Carmangay				
1915	6·5	60·2	...	66·7	...	41·9	...	2·0	43·9	...
1916	...	...	...	...	...	32·6	...	...	32·6	...
1917	17·9	154·3	95·4	267·6	...	31·3	...	...	31·3	...
1918	...	...	...	211·0	...	29·8	...	1·0	30·8	...
1919	...	...	...	194·7	...	32·5	...	1·2	33·7	...
1920	...	...	...	158·9	...	26·2	...	3·4†	30·3	...
1921	...	...	...	137·8	...	...	...	...	...	...
1922	...	...	...	135·7	...	...	...	...	...	...
1923	...	...	...	150·8	...			No Records		
1924	...	...	...	176·8	...	...	...	...	...	...
1925	...	...	...	178·0	...	...	...	...	...	...
1926	...	...	...	174·4	...	...	...	...	...	...
1927	...	...	...	154·6	...	...	...	...	...	...
1928	...	...	...	179·8	...	...	...	...	...	...
	Medicine Hat					Redcliff				
1915	181·0	28·0	15·0	224·0	...	31·1	6·8	...	37·9	...
1916	...	...	...	214·0	...	36·8	22·1	1·0	59·9	...
1917	...	...	...	257·0	...	42·5	30·3	...	72·8	...
1918	...	...	...	264·0	...	61·4	22·4	...	88·8	...
1919	...	...	...	234·0	...	79·1	13·7	...	92·8	...
1920	...	...	...	206·8	...	67·9	16·2	...	84·2	...
1921	...	...	...	175·3	...	65·7	9·6	0·5	75·8	...
1922	...	...	...	187·9	...	97·9	7·8	...	105·6	...
1923	...	...	...	213·4	...	82·9	8·1	...	91·0**	...
1924	...	...	...	222·2	...	136·6	8·4	...	145·0	...
1925	...	...	...	252·3	...	...	...	...	143·4	...
1926	...	...	...	265·7	...	...	...	...	176·2	...
1927	...	...	...	261·9	...	...	...	...	151·4	...
1928	...	...	...	279·8	...	...	...	...	157·5	...
						Athabaska				
1915	...					14·3	...	...	14·3	...
1916	...					10·9	...	...	10·9	...
1917	...					24·0	...		24·0	...
1918	...					27·6	...		27·6	...
1919	...					26·1	...	...	26·1	...
1920	...					44·3	...	...	44·3	...
1921	...					33·3	...		33·3	...
1922	...					...	...		...	...
1923	...					...			...	...
1924	...					18·0	...	...	18·0	...
1925	...					19·1	...	...	19·1	...
1926	...					7·5	...	...	7·5	...
1927	...					11·2	...	...	11·2	...
1928	...					12·6‡	...	...	12·6	...

*4 months. †7 months. ‡6 months. **Based on 4 months' records.

Cities and Towns in the Province of Saskatchewan

Record of Daily Water Consumption in Imperial Gallons for the Year 1928

Month	Estevan—Population 2,500						Moose Jaw—Population 21,000					
	Daily Average for the month	Per Head for domestic purposes	Per Head for industrial purposes	Per Head for other purposes	Per Head for all purposes	Unaccounted for	Daily Average for the month	Per Head for domestic purposes	Per Head for industrial pur poses	Per Head for other purposes	Per Head for all purposes	Unaccounted for
January	....	....	....	....	....	....	1,091,710	36·0	16·0	....	52·0	....
February	....	....	....	....	....	....	1,021,828	33·2	15·5	....	48·7	....
March	....	....	....	....	....	....	1,072,000	34·4	16·6	....	51·0	....
April	....	....	....	....	....	....	1,099,167	35·8	16·5	....	52·3	....
May	....	....	....	....	....	....	1,254,129	42·5	17·2	....	59·7	....
June			No Records				1,210,833	36·4	21·3	....	57·7	....
July	....	....	....	....	....	....	1,437,032	43·9	24·5	....	68·4	....
August	....	....	....	....	....	....	1,642,774	55·1	23·1	....	78·2	....
September	....	....	....	....	....	....	1,334,267	43·4	20·1	....	63·5	....
October	....	....	....	....	....	....	1,314,258	42·8	19·8	....	62·6	....
November	....	....	....	....	....	....	1,326,100	42·7	20·4	....	63·1	....
December	....	....	....	....	....	....	1,303,871	43·7	18·4	....	62·1	....
Average for the year	*60,000	....	....	....	24·0	....	1,258,997	40·8	19·1	....	59·9	....

Month	Weyburn—Population 4,000						Prince Albert—Population 8,000					
January	251,380	62·8	....	....	62·8	....	534,487	30·8	27·7	....	66·8	8·3
February	248·748	62·2	....	....	62·2	....	545,976	29·0	30·2	0·1	68·2	8·9
March	237,756	59·4	....	....	59·4	....	569,265	27·7	26·9	2·0	71·1	14·5
April	210,359	52·6	....	....	52·6	....	627,523	28·1	31·5	1·3	78·4	17·5
May	257,308	64·3	....	....	64·3	....	663,874	30·3	30·5	0·6	83·0	21·6
June	274,104	68·5	....	....	68·5	....	655,233	34·0	29·5	2·8	81·9	16·3
July	288,710	72·2	....	....	72·2	....	705,394	31·1	34·4	2·6	88·2	20·1
August	272,497	68·1	....	....	68·1	....	667,452	32·9	28·6	2·0	83·4	19·9
September	281,475	70·4	....	....	70·4	....	605,333	29·8	35·7	2·3	75·7	7·9
October	277,744	69·4	....	....	69·4	....	596,919	29·9	31·0	0·7	74·6	13·0
November	258,269	64·6	....	....	64·6	....	584,950	32·3	31·4	1·3	73·1	8·1
December	261,164	65·3	....	....	65·3	....	552,323	31·1	28·9	0·7	69·0	8·3
Average for the year	259,960	65·0	....	....	65·0	....	609,061	30·6	30·5	1·3	76·1	13·7

Month	North Battleford—Population 5,100						Kamsack—Population †380					
January	145,426	13·8	0·9	4·3	28·5	9·5	163,206	26·4	255·9	2·6	429·5	144·6
February	115,490	13·6	0·8	0·1	22·6	8·1	147,383	26·8	218·0	1·6	387·8	141·4
March	119,390	16·2	0·4	1·2	23·4	5·6	131,232	25·0	167·2	4·0	345·4	149·2
April	156,777	10·4	0·6	4·6	30·7	15·1	117,070	24·3	149·7	6·7	308·1	127·4
May	251,313	10·5	1·8	5·7	49·2	31·2	120,106	36·2	183·4	0·1	316·1	96·4
June	246,670	13·8	1·0	1·7	48·4	31·9	109,600	37·4	138·4	2·8	288·4	109·8
July	257,500	12·3	1·0	2·4	50·5	34·8	113,939	46·9	140·8	4·9	299·9	107·3
August	295,942	14·7	1·6	1·1	58·0	40·6	90,242	52·9	115·7	4·2	237·5	64·7
September	298,503	15·7	1·6	2·8	58·5	38·5	132,253	49·9	195·1	4·1	348·0	98·9
October	289,835	13·6	0·8	2·3	56·8	40·1	154,003	43·1	254·0	1·0	405·3	107·2
November	298,943	16·4	1·7	4·4	58·6	36·1	146,580	32·5	259·1	0·2	385·7	93·9
December	246,671	10·8	2·0	4·7	48·4	30·9	110,061	27·3	173·4	0·5	289·6	88·4
Average for the year	226,872	13·5	1·2	2·9	44·5	26·9	127,973	35·7	187·6	2·7	336·8	110·8

Month	Regina—Population 50,000						Saskatoon—Population 31,200					
January	2,947,094	53·9	3·7	1·3	58·9	....	2,355,484					‡
February	2,890,983	52·9	3·5	1·4	57·8	....	2,309,655	31·9	20·3	0·9	75·0	21·9
March	2,867,013	52·9	3·2	1·2	57·3	....	2,349,355					
April	2,876,897	50·8	5·7	1·0	57·5	....	2,372,000					
May	3,091,177	56·0	4·7	1·1	61·8	....	2,922,258	31·9	20·1	4·4	87·2	30·8
June	2,968,553	54·0	4·2	1·2	59·4	....	2,863,333					
July	3,127,035	55·3	5·7	1·5	62·5	....	3,079,032					
August	3,463,048	59·9	7·9	1·5	69·3	....	3,028,710	31·2	24·2	6·1	96·8	35·3
September	3,267,170	59·6	4·7	1·0	65·3	....	2,950,000					
October	3,215,874	58·6	4·6	1·1	64·3	....	2,858,065					
November	3,147,717	56·5	5·2	1·2	62·9	....	2,745,000	37·1	24·9	1·2	87·1	23·9
December	3,094,412	55·5	4·5	1·9	61·9	....	2,545,484					
Average for the year	3,079,748	55·5	4·8	1·3	61·6	....	2,698,198	33·0	22·4	3·1	86·5	28·0

Record of Daily Water Consumption in Imperial Gallons for the Year 1928 —Continued

Month	Kindersley—Population 1,000					
	Daily Average for the month	Per Head for domestic purposes	Per Head for industrial purposes	Per Head for other purposes	Per Head for all purposes	Unaccounted for
January	....	....	....	....	....	....
February	....	....	....	....	....	....
March	....	....	....	....	....	....
April	....	....	....	....	....	....
May	....	....	....	....	....	....
June	....	....	....	....	....	....
July	....	....	....	....	....	....
August	....	....	....	....	....	....
September	....	....	....	....	....	....
October	....	....	....	....	....	....
November	....	....	....	....	....	....
December	....	....	....	....	....	....
Average for the Year	**15,000	15·0	....	....	15·0	....

*Estimated daily consumption as furnished. by Town. Daily records for 1928 not available.
†Only 76 consumers, or approximately 380 persons, supplied. This figure is used in computations, although total population is about 2,100.
‡Includes Town of Sutherland.
**Estimate of daily average for the year furnished by the town. No daily records.

Record of Average Daily Water Consumption in Imperial Gallons, Years 1915-1928 (Inclusive)

Average for Year	Per Head Domestic	Per Head Industrial	Per Head other purposes	Per Head all purposes	Unaccounted for
	Estevan				
1915	9·5	7·1	1·5	18·1	....
1916	8·2	5·7	1·0	14·9	....
1917	9·7	5·5	4·3	19·5	....
1918	9·3	0·7	7·2	17·2	....
1919	9·6	2·9	....	12·5	....
1920	9·3	4·4	....	13·7	....
1921	6·1	4·7	2·0	12·8	....
1922	8·5	6·4	2·9	17·9	....
1923	8·6	10·8	1·4	20·3	....
1924	9·2	6·1	2·9	18·2	....
1925	....	....	....	16·8	....
1926	....	....	....	20·1	....
1927	....	....	....	25·3	....
1928	....	....	....	24·0	....

Record of Average Daily Water Consumption in Imperial Gallons for Years 1915-1928 (inclusive)

Average for Year	Per Head Domestic	Per Head Industrial	Per Head other purposes	Per Head all purposes	Unaccounted for	Per Head Domestic	Per Head Industrial	Per Head other purposes	Per Head all purposes	Unaccounted for
	Regina					Saskatoon				
1915	55·0	7·5	0·1	62·6	...	21·6	13·9	2·2	45·6	7·9
1916	66·1	7·8	...	73·9	...	21·0	15·4	1·9	52·6	14·3
1917	59·2	12·6	0·3	72·1	...	24·4	15·6	5·8	66·4	20·6
1918	56·9	11·1	0·1	68·1	...	27·1	17·2	2·4	63·1	16·4
1919	42·8	8·3	...	51·2	...	28·0	16·3	1·9	64·1	17·9
1920	48·9	9·1	0·9*	58·8	...	29·4	14·3	6·1	74·1	24·4
1921	49·6	10·1	2·1	62·6	0·8	29·5	20·3	1·1	72·1	21·2
1922	59·2	12·6	2·5	74·5	...	31·0	23·6	1·5	78·4	22·4
1923	61·7	14·5	2·0	78·2	...	28·8	20·8	1·5	71·0	23·1
1924	65·1	9·7	1·5	76·7	0·4	27·9	19·2	2·4	69·3	19·8
1925	72·1	4·4	1·5	78·0	...	31·4	20·5	3·0	81·0	26·1
1926	72·0	4·8	1·4	78·2	...	29·5	17·8	2·8	73·0	22·9
1927	71·3	6·5	1·8	79·6	...	28·2	19·2	2·5	76·3	26·4
1928	55·5	4·8	1·3	61·6	...	33·0	22·4	3·1	86·5	28·0
	Moose Jaw					North Battleford				
1915	24·1	4·6	...	28·7	...	6·6	1·3	2·7	14·8	4·2
1916	35·2	12·3	...	47·5	...	9·5	2·0	4·9	22·7	6·3
1917	45·8	13·1	...	58·9	...	10·2	2·2	4·0	23·1	6·7
1918	31·6	15·4	...	47·0	...	10·0	4·8	3·0	26·3	8·5
1919	24·8	15·1	...	39·9	...	11·5	1·6	4·4	29·7	12·2
1920	24·5	14·5	...	39·1	...	11·3	5·8	5·9	34·0	10·9
1921	30·9	3·9	6·2	41·0	...	9·7	2·8	2·9	26·7	11·3
1922	34·8	9·0	...	43·8	...	11·0	2·8	4·3	34·1	15·9
1923	34·9	9·4	...	44·3	...	11·3	1·6	4·4	25·0	7·7
1924	36·5	8·0	...	44·5	...	10·8	2·3	3·7	33·4	16·6
1925	33·0	9·7	...	42·7	...	11·0	1·8	4·9	31·8	14·1
1926	33·1	14·3	...	47·4	...	11·7	2·3	3·3	30·9	13·6
1927	31·9	19·2	...	51·1	...	10·7	0·9	4·1	29·2	13·5
1928	40·8	19·1	...	59·9	...	13·5	1·2	2·9	44·5	26·9
	Weyburn					Kindersley				
1915	17·4	...	0·4	17·8	...	4·9	8·4	1·6	14·9	...
1916	16·9	...	0·3	17·2	...	5·5	26·8	...	32·3	...
1917	30·1	...	...	30·1	...	5·8	44·4	...	50·2	...
1918	26·4	...	...	26·4	...	6·0	8·9	...	14·9	...
1919	25·5	...	...	25·5	...	7·8	...	...	7·8	...
1920	30·2	...	...	30·2	...	6·9	17·5	...	21·5	...
1921	27·1	...	...	27·1	...	8·5	11·0	...	19·5	...
1922	...	...	...	64·4	...	10·1	12·3	...	22·4	...
1923	...	...	...	68·0	...	11·5	...	...	11·5	...
1924	...	...	...	77·4	...	11·0	...	...	11·0	...
1925	...	...	...	64·1	...	6·4	...	...	6·4	...
1926	61·8	...	...	61·8	...	10·0	...	...	10·0	...
1927	66·0	...	...	66·0	...	No Records			...	...
1928	65·0	...	...	65·0	...	15·0	...	...	15·0	...
	Kamsack					Prince Albert				
1915	...	...	...	...	...	...	...	...	...	...
1916	...	...	...	...	...	...	...	...	...	...
1917	...	...	...	...	...	...	...	...	...	...
1918	31·6	66·3	...	97·9	...	...	...	...	...	...
1919	...	...	...	...	...	...	...	...	...	...
1920	...	...	...	...	...	...	...	...	...	...
1921	50·4	724·9	...	775·3	...	...	...	...	83·0	...
1922	50·3	690·2	...	740·5	...	20·4	23·2	1·9	69·6	20·1
1923	27·3	291·5	...	478·5	159·7	22·8	27·1	1·6	70·0	18·5
1924	24·8	194·4	...	394·2	175·0	24·2	28·7	1·5	65·4	11·0
1925	23·3	190·6	...	405·5	191·6	29·2	30·2	1·3	70·6	9·9
1926	26·5	177·5	6·4	334·8	133·4	28·4	31·5	1·0	69·4	8·5
1927	29·3	187·6	1·6	338·5	120·0	28·5	31·6	1·5	75·1	13·5
1928	35·7	187·6	2·7	336·8	110·8	30·6	30·5	1·3	76·1	13·7

*10 months.

General River Control

Due to chinooks in January and extremely warm weather in March a great deal of the run-off from the prairie snows occurred during those two months and, as April and May were months of low precipitation, very little trouble was experienced from floods or unusually high water during the period of run-off from the mountain snows in 1928. Consequently few complaints regarding flooding reached the Department for investigation.

South Saskatchewan River.—Information reached the Calgary office on March 31 of unusual flood conditions on the South Saskatchewan river at Pike lake, some 15 miles south of Saskatoon. It was thought advisable to have an engineer from the Department proceed to the scene of the trouble to investigate conditions and causes of the flood. It was found that the flood was due to ice-jams caused by the early break-up of the ice in the upper tributaries of the river. This ice was carried to the lower reach of the river before the ice cover had broken out in that section and jamming behind this ice cover caused back-water which flooded over the low-lying lands in the Pike Lake district. As the lower portion of the river broke out rapidly the situation was relieved in two or three days without any great damage having been done.

Highwood River.—A stretch of some 4 miles of the Highwood river through range 29 in the vicinity of the town of High River periodically overflows its banks, some of this flow returning to the river through Baker creek which parallels the river at this section and a portion finding its way to the Little Bow river which has its source practically on the bank of the Highwood river in the above range. Successive floods in the Highwood river have gradually cut away the banks each year and have increased the danger of the river changing its course to the Little Bow valley and thus injuriously affecting water-rights granted from the Bow river, of which the Highwood river is an important tributary. Excessive bank erosion has also threatened a considerable portion of the town of High River.

In the year 1917 a very bad break occurred in the river bank in the south-east quarter of section 32, township 18, range 29, and suitable works were designed and built by this Department which successfully withstood floods until 1923 when an unprecedented period of high water partially washed them out. The works were immediately repaired by this department in co-operation with the Provincial Department of Public Works. Since that time other works have been constructed by the town of High River assisted by the Dominion and Provincial Public Works Department. During the year 1927-28 the river cut into its banks at two points, one near the power house in the town of High River and the other some 3 miles above the town in section 33, township 18, range 29. There is not much danger of the Highwood river cutting through to the Little Bow valley at the lower point but investigation showed that the danger was grave at the upper point and that a flood of a few days' duration would cut a channel to Baker creek when it would only be a matter of time until a channel was cut to the Little Bow river. This Department in co-operation with the Dominion and Provincial Departments of Public Works made investigation and surveys of the threatened points during the years 1927 and 1928 and joint action was taken to construct protection works. These works were completed during the autumn of 1928.

East and West Prairie Rivers.—Periodic flooding of lands adjacent to the East and West Prairie rivers occurs in the vicinity of High Prairie, Alberta. An investigation of conditions was made by the Reclamation Service in 1919 with a view to determining the best means of relieving the situation and reclaiming flooded areas. The survey was carried out under adverse weather

conditions. A full report dealing with the cause of the flooding was submitted to the Department with plans for the necessary remedial works. The cost of the works was found to be excessive and the proposed reclamation was not proceeded with. As the flooding is caused by the yearly formation of driftwood jams which remain in the river bed and silt up after the flood waters pass, the conditions grow more aggravated each season. A request was made to the Department during 1928 on behalf of the settlers in the district affected for a further investigation to determine if some measure of flood control could not be instituted. A survey was carried out by officers of this service and a report submitted with recommendations which have been held for further consideration and investigation.

Major Irrigation Projects

THE CANADIAN PACIFIC RAILWAY COMPANY

Western Section.—This project diverts water from the Bow river in section 13, township 24, range 1, west of the 5th meridian, just east of the city of Calgary, and has been in operation for 21 years. At the close of the year 1928 there were 209,039 acres held under water agreement as compared with 202,096 in 1927, an increase of 6,943 acres. The number of water users was 498 as compared with 352 in 1927.

Water was turned into the system on May 9 and the headgates closed on September 29. During the past season's operations 80,700 acre-feet of water were diverted from the Bow river. The highest daily discharge recorded was 789 on July 19 and the average daily flow for the month of maximum demand was 448 cubic feet per second during May.

During the past season 3,890 acres were irrigated, a slight increase over 1927. The total cropped area was 231,550 acres producing $4,974,000 based on average values in the irrigation districts, or representing a per-acre return of $21.50. Of the total cropped area 173,700 acres were in wheat which produced 4,143,480 bushels or at the rate of 24·1 bushels per acre. Other crops on this project included oats 30,270 acres, barley 9,775 acres, hay crops 11,020 acres.

The early part of the season was dry and windy and the rainfall during the month of May was below average but soil moisture conditions were adequate for germination. More favourable conditions developed during June when a rainfall of 6·33 inches was received. July was also a very favourable month for crop growth and with a rainfall of 2·94 inches the district showed promise of a record yield. Unfortunately an early frost did considerable damage on August 28 and on September 8 a heavy frost throughout the project greatly reduced the grade of all standing grain.

The period free from frost covered 110 days from May 10 to August 28 or 18 days shorter than in 1927. The total precipitation recorded at the Canadian Pacific Railway Company's operating headquarters at Strathmore for the year was 17·73 inches. The seasonal precipitation recorded in inches is as follows: May, 0·1; June, 6·33; July, 2·94; August, 1·34; September 0·07; or equal to 10·78 inches.

Maintenance work during the year included the following:—

83 miles of ditches cleaned out by mechanical excavators.
29 miles of ditches cleaned out by teams.
263 structures repaired.
377 structures renewed.

The estimated total yardage of earth moved during the season was 135,000, of which 55,000 was done by "D.N.R." excavator, 55,000 by drag line excavators and 25,000 by team-work. A considerable portion of the lumber used for renewals was creosoted.

The live stock situation is improving from year to year and many of the farmers are building up valuable herds. A few farmers have started to raise black and silver foxes and there are at the present time some 230 in the district.

Eastern Section.—This project diverts water from the Bow river at the Horseshoe Bend dam on the Blackfoot Indian Reserve in township 21, range 19, west of the fourth meridian, and has been in operation for 15 years. At the close of the year 1928, 78,588 acres were held under water agreement as compared with 69,690 acres in 1927. The number of water users was 587 as compared with 578 in the previous year.

Water was turned into the system on May 3 and the headgates closed on October 5. During the season's operations 274,500 acre-feet of water were diverted from the Bow river. The highest daily discharge recorded was 1,702 cubic feet per second on June 3 and the average daily flow for the month of maximum demand was 1,358 cubic feet per second during June.

During the past season 45,680 acres were irrigated, an increase over 1927 of some 37,760 acres. The total cropped irrigable area was 45,680 acres producing crops valued at $864,480 based on the average unit values for southern Alberta or representing a per acre return of $18.90. On the irrigated lands the area in wheat was 23,090 acres which produced 495,880 bushels or 21·5 bushels per acre. Other staple crops included oats 2,961 acres yielding 30·5 bushels per acre, barley 1,665 acres yielding 30·3 bushels per acre, alfalfa 11,180 acres yielding 1·7 tons per acre.

The season was not wholly favourable for plant growth. During May soil conditions generally were too dry and seed germination was slow and in many cases uneven. More favourable conditions prevailed throughout June and July when moisture requirements were entirely satisfied by rainfall. During August maturity was retarded by cool temperatures and in certain localities crops were damaged by frost. The total precipitation recorded for the 12 months at the Canadian Pacific Railway Company's operating headquarters at Brooks was 12·62 inches, of which 1·50 was received between January 1 and May 31. The seasonal precipitation in inches as recorded at the Dominion Experimental Station two miles west of Brooks is as follows: April, 0·42; May, 0·09; June, 4·53; July, 3·62; August, 0·16; September, 0·10; October, 0·48; or equal to a total of 9·40 inches.

The company maintains an efficient organization furnished with all modern equipment and appliances necessary for maintaining their works in a satisfactory state of repair. During the year the following work has been carried out in connection with the maintenance and operation of the project:—

116 miles of ditches cleaned out by mechanical excavators.
216 timber structures repaired.
26 concrete structures repaired.
143 timber structures renewed.
63 new structures.
3 new concrete structures.

The estimated total yardage of earth moved during the season was 694,000 of which 62,000 cubic yards was done by "D.N.R." excavators, 557,000 by drag line excavators and 75,000 by teams.

An extensive system of drainage ditches recently built throughout the project should greatly improve conditions generally and will provide outlets for surplus surface irrigation water. Some 63 miles of drainage ditches have been built during the season.

Lethbridge Section.—This project diverts water from the St. Mary river, the headworks being located in section 36, township 1, range 25, west of the 4th meridian, 6 miles north of the international boundary, and has been in

operation for 29 years. At the close of the year 1928, there were 75,555 acres held under water agreement as compared with 72,742 acres in 1927. The Magrath and Raymond irrigation districts receive their water supplies through the company's works, the Magrath district for 5,047 and Raymond district 6,441 acres. The total area now being served through these works is therefore 87,040 acres. The number of water users was 912 as compared with 349 in 1927.

Water was turned into the system on May 10 and the headgates closed on October 6. During this period 106,000 acre-feet of water were diverted from the St. Mary river. The highest daily discharge recorded was 894 on June 4, and the average daily flow for the month of maximum demand was 478 cubic feet per second during June. The area irrigated was 22,085 acres and the area cropped but not irrigated was 39,500, a total cropped area of 61,585 acres. The total return from the irrigated land was valued at $633,221, or $28.60 per acre and from the area not irrigated $1,038,130 or $26.28 per acre. The major crop was wheat which represented 57 per cent of the total cropped area and produced an average yield of 31·34 bushels per acre on the irrigated land and 27·4 on the non-irrigated area.

The period free from damaging frosts extended from April 22 to September 8, or equal to 133 days as compared with 140 days in 1927. The total precipitation recorded at Lethbridge during the year was 18·08 inches and the seasonal (May to September) precipitation recorded was 12·64 inches. The average monthly precipitation at Lethbridge for the past 27 years is as follows: January, 0·64; February, 0·69; March, 0·70, April, 0·96; May, 2·48; June, 2·92; July, 1·90; August, 1·70; September, 1·76; October, 0·83; November, 0·66; December, 0·62.

The early seeding period was favourable and soil moisture conditions satisfactory, but owing to a period of high winds during May the fields became very dry and much grain had to be irrigated. Fall wheat and early-sown wheat on summer-fallow lands produced good yields, ripening well ahead of the frost. During the first week in June more water was carried in the main canal than during any previous period of peak-load.

Very little work has been done on maintenance during the past season and that principally in connection with renewals of major structures. The wooden flume across Rolph creek in section 21, township 2, range 24, west of the 4th meridian has been dismantled and is being replaced with a creosoted wood-stave syphon with concrete portals. This work was commenced in October and the contract calls for its completion by March 15, 1929. At the headworks on the St. Mary river some repair work was carried out in connection with the re-flooring of the sluiceway section.

Taber Irrigation District

This district receives its water-supply from the St. Mary river through the works of the Alberta Railway and Irrigation Company, previously referred to in this report as the Canadian Pacific Railway Company's Lethbridge Section. The 1928 operating season was the eighth since construction of the system. At the close of the year there were 21,571·3 irrigable acres in the district, an increase of 4,631·5 over 1927. The additional area included represents 3,008·3 acres of former School lands and 1,653·2 acres of privately owned land brought into the district by change of content and a decrease of 30 acres due to revised classifications.

Water was turned into the system on May 13 and the headgates closed on November 15. During the season 14,546 acre-feet of water were diverted from the Chin Coulee Storage reservoir. The highest daily discharge recorded was 132 cubic feet per second on November 13 and the average daily flow for the month of maximum demand was 44·3 cubic feet per second during June.

The area irrigated by 161 water users was 3,170 acres, 1,570 during the summer months and 1,600 during the fall. The total cropped irrigable area was 15,880 acres producing $470,050 based on the unit value used for southern Alberta, or representing a per acre return of $29.60.

The principal crop was wheat which represented 44 per cent of the cropped area on irrigable land. The sugar beet area was 2,270 acres, an increase over 1927 of 640 acres. The average yield was 8·3 tons per acre. The saccharine content averaged 17·33 per cent for all projects supplying beets to the factory. As this crop averaged the farmer $8.25 per ton, the total revenue to the district amounted to $155,067 and the per acre return $68.30. This crop has been a very satisfactory one for the district. The farmers have found it profitable and their lands have been benefited, the intensive cultural methods necessarily followed having very effectively controlled noxious weeds.

From the secretary-manager's annual report to the water-users of the district, it is noted that considerable expenditures have been made on maintenance account. Eight seasons of continuous operation had so reduced the carrying capacity of many of the important distributary canals that it became imperative to remedy the condition. Fortunately for the district the Canadian Pacific Railway Company had available a "D.N.R." excavator at Coaldale and this was rented by the month. The machine started operations on July 16 and worked continuously until October 30, during which period some 18·39 miles of canal were cleared out. Other minor repairs were made to the timber structures throughout the district.

Construction work to serve lands at the west end of the district, included by change of content in January, 1928, was started on June 28. The earthwork contract for the lateral ditches was let to a local contractor at a rate of 23 cents per cubic yard. The enlargement of the first 8·2 miles of the main canal was undertaken by the district and a drag line excavator was rented from the Canadian Pacific Railway Company for the purpose. This machine started to work on June 28 and ceased operations on October 31, a distance of some 7·38 miles having been completed. It is estimated that the remaining 4,200 feet should be finished in from 12 to 14 days. The cost per mile for that portion completed has been $546. The canal has been enlarged to an average width of 18 feet, silt removed and banks re-sloped.

About 90 per cent of the earthwork contract for the lateral ditches has been completed and it is estimated the balance of the work can be completed before water will be required on the land in the spring of 1929.

Timber construction work was undertaken by day labour hired by the district. Eight bank gates on the main canal, 13 highway culverts, 2 farm bridges and 50 delivery gates were constructed and a total of 42,978 feet board measure of lumber used.

The original estimate of cost was $25,182 and it is anticipated the work will be completed well within this figure.

Canada Land and Irrigation Company

This project diverts water from the Bow river in section 31, township 21, range 25, west of the 4th meridian, 1½ miles southeast of the town of Carseland on the Canadian Pacific Railway.

The season was a difficult one from an operation and maintenance standpoint. A very dry and windy spring caused soil and weeds to drift across the country and sections of canal and many bridges and canal structures became partially blocked. The flow of water in the canals was thus seriously retarded and necessitated the immediate removal of these obstructions. Owing to these unfavourable conditions a very poor seed bed resulted and many farmers were

forced to irrigate their grain to ensure germination. There was a heavy demand for water until the second week in June when the whole district received plenteous rainfall. These favourable conditions prevailed throughout the remainder of June and July and in consequence very little water was used for irrigation.

Water was turned into the system on May 22, 1928, and the headgates on the Bow river closed on October 31, 1928.

Diversions from the Bow river to Lake McGregor reservoir were made from April 22 to October 31 and a total of 45,000 acre-feet diverted. Storage in this lake was reduced from 85,530 acre-feet as at April 1 to 78,805 acre-feet on November 30. Storage in the Little Bow reservoir was increased from 6,080 acre-feet to 13,624 acre-feet for a similar period. The total water delivered from the Little Bow reservoir was 31,113 acre-feet, of which 4,093 acre-feet were delivered to the New West Irrigation district, 15,016 acre-feet to the water users of the company and some 12,004 acre-feet accounted for in water delivered for stock-watering and domestic use, canal losses and waste.

The highest daily discharge recorded was 254 cubic feet per second on May 24 and 28 and the average daily flow for the month of maximum demand was 162 cubic feet per second during May.

During the past season 15,680 acres were irrigated. The total cropped area on the project was 21,050 acres producing crop values amounting to $408,440 based on a general average unit value for southern Alberta, and represents a per-acre return of $19.40. The area in wheat was 16,630 acres which produced 327,570 bushels, or at the rate of 19·7 bushels per acre. Other staple crops grown included—oats 1,530 acres yielding 24·4 bushels per acre, barley 290 acres yielding 15·3 bushels and alfalfa 1,630 acres yielding 1·6 tons per acre.

During the year the company has again carried out a fairly comprehensive development program. On division 'A' the concrete foundations for flume No. 1 were partly reconstructed in readiness for a new flume. On division 'B' miscellaneous enlargements were made to the main canal to increase its capacity to 400 cubic feet per second. A new 14-foot diameter steel flume was also built to replace one of 10 foot diameter across an earth slide, greatly increasing canal capacity at this point. On the lower section of this division a concrete chute was built for a wasteway at the site of the Mile Wide Valley flume. Five new concrete check gates were completed as to foundations and pouring and the forms placed in readiness to complete upper parts of these structures in the spring of 1929. In the western district 15·83 miles of lateral ditches and 2·61 miles of drainage ditches were built together with 118 lateral structures. In the southern part of the Alberta district surveys were made for the classification of lands. Land sales during the calendar year 1928 have been satisfactory, the company having disposed of 7,300 acres. The total irrigable area under agreement is 31,736 acres, of which 4,501 is in the New West Irrigation District.

New West Irrigation District

The water-supply for this district is obtained from the Bow river through the works of the Canada Land and Irrigation Company, the point of diversion from the company's main canal being in the northeast quarter of section 36, township 13, range 17, west of the fourth meridian. The district contains an irrigable area of 4,501 acres and has 24 water users.

Water was turned into the system on May 19 and the headgates closed on October 8. During the season's operations 3,960 acre-feet were diverted from the Bow river through the company's system. The highest daily discharge recorded was 56 cubic feet per second on June 5 and the average daily flow for the month of maximum demand was 34·4 cubic feet per second during June.

The area irrigated was 3,630 acres and the total area under crop was 4,800 acres producing $81,030, based on the unit values used for southern Alberta, or representing a per-acre return of $16.85.

The major crop was wheat which represented some 85 per cent of the total irrigable area and yielded an average of 18·2 bushels per acre. Other crops grown included barley, oats, rye, green feed, alfalfa, and sweet clover. Of the 96 acres devoted to alfalfa seed production 45 per cent was destroyed by worms and of the 35 acres of sweet clover grown for the same purpose all was lost.

The farmers of this district were somewhat delayed in their spring seeding operations due to unsuitable weather. Moisture conditions were favourable at the outset but heavy winds which persisted during the first three weeks of May seriously depleted the available surface moisture from the spring ploughed land. This created a serious situation and compelled most of the farmers to irrigate their grain. From June 17 until the end of July generous rains were received, and very little water was used for irrigation during the remainder of the season. Crop conditions improved in June and July, but unfavourable weather in September resulted in a low yield.

The bonded indebtedness at the close of the year was $209,500, the amount expended on repairs $340, and the total cost of management $2,237. The district is gradually becoming established and is now in a sound financial position.

The maintenance program consisted of general repairs to structures, the installation of farm delivery gates and of farm bridges. Some work was also done raising ditch banks, removal of silt and burning and removing weeds from ditches and structures.

Considerable attention has been given by the operating staff to the eradication of noxious weeds on canal banks and on canal right of way.

Lethbridge Northern Irrigation District

The district diverts its water from the Oldman river at a point in the Peigan Indian reserve about the centre of township 8, range 27, west of the 4th meridian and has been in operation for five years.

The total classified irrigable area as at the close of 1928 was 102,119·45 acres, of which 33,440 were irrigated during the past season as compared with 10,010 in 1927. The number of water-users was 744 as compared with 558 in 1927. Water was turned into the system on May 3, and the headgates closed on October 21. During the period under operation 77,788 acre-feet of water were diverted from the Oldman river, representing an average daily flow equal to 213 cubic feet per second. The highest daily discharge recorded was 592 cubic feet per second on June 2, and the average daily flow for the month of maximum demand was 366 cubic feet per second during June. Owing to the porous nature of the first $2\frac{1}{2}$ miles of the main canal, which passes through a gravel formation, some 16,288 acre-feet of water returned to the Oldman river during the season by seepage. The quantity of water which was actually delivered into the system was therefore only 61,500 acre-feet.

The total cropped irrigable area was 107,160 acres producing $1,616,140 based on the unit values used for southern Alberta or representing a per-acre return of $15.10. Of the total cropped area 72,806 acres were in wheat which produced 949,650 bushels or at the rate of 13 bushels per care. Other crops on irrigable land included oats 5,560 acres, barley 2,310 acres, hay crops 8,670 acres.

The wet fall of 1927 and the favourable conditions which prevailed until the end of April were very encouraging to the farmers and seeding proceeded apace with little thought of any preparations for irrigation. The month of May, however, proved disappointing as precipitation was much below average, only one-tenth of an inch being recorded. In addition strong southwesterly winds prevailed and the surface of the land became so dry that germination was poor. As a result of these conditions a sudden and urgent demand for

water developed towards the end of May. From June 6, until the end of July an adequate rainfall occurred, in fact the precipitation at Lethbridge for the two months was 10·77 inches, considerably above the average for the past 27 years of record. A very promising crop was in prospect at the end of July but unfavourable weather later reduced the yield. The decline in the price of all grains and fodder greatly reduced the net returns of the farmers to a point considerably below that of 1927. Livestock and poultry products, however, brought higher prices, tending to compensate for the decreased revenue from other sources.

The total precipitation recorded at the Dominion Government Experimental Station 2 miles east of Lethbridge was 18·08 inches, of which 12·64 inches were received between May 1 and September 30.

During the year the district's officials have been confronted with a number of claims for damages caused by seepage from canals and the rise of ground water. These claims have been dealt with and payments made from a reserve fund which has been created by the district from the water service charges. In many cases permanent settlements have been made.

The water service rate levied per irrigable acre for the operation of the system was $1.25 and in addition to this there was a water-right rate of $3.25, making a total annual charge against each acre of land of $4.50. The amount expended on repairs and maintenance was $91,190 and the total bonded indebtedness at the close of the year was $5,540,000.

The control of noxious weeds and the removal of silt and drift from the ditches has been the cause of considerable expense to the district.

Progress in the colonization of the remaining lands in the district has been satisfactory, several new settlers having taken up land during the year.

United Irrigation District

This district diverts its water from the Belly river in section 13, township 3, range 28, west of the 4th meridian. At the close of the year there were 34,248 acres classified as irrigable as compared with 34,410 in 1927, the reduction being due to revised classifications. The number of water-users was 95 as compared with 145 in 1927.

Water was turned into the system on May 11, and the headgates closed on October 31. During the season's operations 11,900 acre-feet of water were diverted from the Belly river. The highest daily discharge recorded was 91 cubic feet per second on August 25, and the average daily flow for the month of maximum demand was 51 cubic feet per second during August.

During the past season 2,580 acres were irrigated. The total cropped irrigable area was 25,490 acres which produced crop values amounting to $408,140, or representing a per-acre return of $16. On the irrigated lands the area in wheat was 18,495 acres which produced 416,172 bushels or at the rate of 22·5 bushels per acre.

The early spring was cold and wet but during May high winds caused much depletion of soil moisture with the result that demands were made for water for irrigation immediately after completion of seeding. During the second week in June conditions changed and adequate rainfall until the end of July rendered irrigation unnecessary.

Early frosts did considerable damage to wheat crops throughout the district reducing both yield and grade. Little new settlement has taken place and very little new land has been broken during the year.

The rate levied per irrigable acre for the operation of the system was 47 cents and the amount expended on repairs and maintenance was $2,456. The total bonded indebtedness at the close of the year was $536,978.

The maintenance program included

- 8 miles of lateral ditches cleaned out.
- 82 timber structures repaired.
- 15 concrete structures repaired.

The estimated total yardage of earth work moved during the season was 1,000.

Magrath Irrigation District

This district obtains its water from the St. Mary river, the supply being carried through the works of the Alberta Railway and Irrigation Company to the district's headgates.

The construction of the system was completed during the summer and the official opening took place at Magrath on June 24, 1927, when water was turned into the main canal for priming purposes.

The area now being administered by the district includes 5,047 acres for which the new works have been constructed and in addition 1,928 acres of water-right lands formerly operated by the Alberta Railway and Irrigation Company, making a total of 6,975 acres of irrigable land. During the season 800 acres were irrigated or 11·4 per cent of the area.

There are two diversion headworks to serve the lands now included in this district, one located on the southwest ¼ of section 9, township 5, range 22, west of the 4th meridian, and referred to as the Magrath Lateral Headgates, and the other in the southwest ¼ of section 28, township 4, range 23, west of the 4th meridian, and known as the Spring Coulee Headgates. Water was turned into the Spring Coulee canal on May 18 and the headgates closed on October 6, a total of 2,030 acre-feet being diverted. The maximum daily discharge recorded was 23·7 cubic feet per second on May 27. The headgates of the Magrath lateral were opened on May 17 and closed on October 6. A total of 2,140 acre-feet was diverted and the maximum daily discharge recorded was 30·3 cubic feet per second on May 28.

The bonded indebtedness at the close of the year was $200,000 and the total amount expended on construction to date was $80,000.

Raymond Irrigation District

This district receives its water supply from the St. Mary river through the works of the Alberta Railway and Irrigation Company. The district has an agreement with the company whereby 40·0 cubic feet of water per second is delivered during the irrigation season of the district's headgates in the NE. ¼ of section 5, township 6, range 21, west of the 4th meridian.

The district's newly constructed works serve 6,441·2 irrigable acres and in addition the district operates and supplies service to 8,688·5 irrigable acres, under an agreement with the Alberta Railway and Irrigation Company.

The total irrigable area in the district is, therefore, 15,129·7 irrigable acres. The operation and maintenance of the system is in charge of a watermaster appointed by the district.

Project Crop Returns

In order to arrive at a fair comparison of the per-acre returns from the various projects it has been considered desirable to establish uniform unit values for this purpose. Tables based on such unit values have therefore been prepared summarizing the crop returns submitted by each of the irrigation districts. It should be noted, however, that the data thus supplied include crops grown within the district on the total area cultivated, whether actually irrigated during the season or farmed as "dry" land. These tables, which appear hereunder, afford a very interesting study of the per-acre returns from the various projects. It is of particular interest to note that the districts having the highest percentage of alfalfa and sugar beets show the highest returns per acre.

Crop	Unit Values	Lethbridge Northern			A. R. & I. Co. C.P.R. Lethbridge Section		
		Acres	Yield per acre	Value per acre	Acres	Yield per acre	Value per acre
	$			$			$
Forage—							
Alfalfa	13 00	4,360	1·600t	20·808	8,049	2·019t	26·247
New alfalfa	13 00	1,047	0·105t	1·365	178	1·107t	14·391
Sweet clover	10 00	....	....	....	35	1·171t	11·710
Alfalfa and timothy	14 00	....	....	....	1,334	1·779t	24·906
Green feed	12 00	1,912	1·153t	13·485	1,285	1·892t	22·704
Timothy	14 00	....	....	....	1,994	1·079t	15·106
Grass hay	11 00	1,355	1·263t	13·900	2,338	1·494t	16·434
Pasture—							
Mixed grass	....	16,807	....	25·000	3,064	....	25·000
Sweet clover seed	....	....	....	....	50	15·00*	0·900
Grains—							
Wheat	1 00	72,806	13·043b	13·043	35,355	27·696	27·696
Winter wheat	....	....	....	....	....	....	....
Oats	0 50	5,564	22·945b	11·472	3,763	41·025b	20·512
Barley	0 56	2,314	12·563b	7·035	1,726	36,017b	20·170
Rye	0 90	377	5·819b	5·237	112	4·277b	3·849
Flax	2 00	78	5·333b	10·666	121	16·082b	32·164
Roots—							
Beets	8 25	....	....	....	838	6·200t	51·150
Potatoes	18 00	184	1·201t	21·618	938	4·363t	78·534
Cultivated—							
Corn stover	4 00	....	....	....	57	7·053t	28·212
Sunflowers	3 00	....	....	....	1	7·000t	21·000
Garden	20 00	356	3·000t	60·000	299	4·715t	94·300
Peas	2 00	....	....	....	3	21·667b	43·334
Other roots	20 00	....	....	....	45	8·355t	167·100
Miscellaneous	....	....	....	....	....	....	....
Total Crop Area	....	107,160	....	15·076	61,585	....	27·107
Summer-fallow	....	12,693	....	....	19,932	....	....
Unbroken land	....	14,526	....	....	15,814	....	....
Idle land	....	15,000	....	....	2,587	....	....
Total arable land	....	149,379	....	....	99,918	....	....

Crop	Unit values	United Irrigation District			C.P.R. Western Section		
		Acres	Yield per acre	Value per acre	Acres	Yield per acre	Value per acre
	$			$			$
Forage—							
Alfalfa	13 00	1,098·0	2·287t	29 73	2,156	1·98t	25 74
New alfalfa	13 00	166·0	....	....	238	0·43t	5·59
Sweet clover	10 00	200·0	....	....	557	0·98t	9·80
Alfalfa and timothy	14 00	....	....	....	....	....	....
Green feed	12 00	630·0	1·409t	16 91	5,943	1·07t	12·84
Timothy	14 00	489·0	1·634t	22 87	519	1·36t	19·04
Grass hay	11 00	468·0	1·182t	13 00	4,609	0·93t	10·23
Pasture—							
Mixed grass	....	10,562	....	25·00	2,095	....	25·00
Grains—							
Wheat	1 00	22,268·56	21·80b	21·80	173,699	24·10b	34·10
Winter wheat	....	165·0	27·09b	27·09	....	....	....
Oats	0 50	1,381·0	37·52b	18·76	30,266	26·10b	13·05
Barley	0 56	1,164·0	27·47b	15·38	9,775	22·85b	12·80
Rye	0 90	....	....	....	408	13·24b	11·92
Flax	2 00	....	....	....	....	....	....
Roots—							
Beets	8 25	605·96	3·696t	30·49	....	....	....
Potatoes	18 00	31·8	4·056t	73·01	143	3·91t	70·38
Cultivated—							
Corn stover	4 00	....	....	....	....	....	....
Sunflowers	3 00	....	....	....	....	....	....
Garden	20 00	40·5	2·376t	47·52	....	....	....
Peas	2 00	....	....	....	....	....	....
Other roots	20 00	....	....	....	....	....	....
Miscellaneous	....	2,360	....	Hailed	1,012	....	20·00
Total Crop Area	....	41,721·82	....	21·160	231,550	....	21·50
Summer-fallow	....	11,473·0	....	....	116,525	....	....
Unbroken land	....	....	....	....	79,373	....	....
Idle land	....	1,377·0	....	....	4,709	....	....
Total Arable Land	....	54,571·82	....	....	432,157	....	....

t = tons. b = bushels. * = pounds.

Crop	Unit values	C.P.R. Eastern Section			Canada Land and Irrigation Co.		
		Acres	Yield per acre	Value per acre	Acres	Yield per acre	Value per acre
	$			$			$
Forage—							
Alfalfa	13 00	13,617	1·60t	20·80	1,629·6	1·63t	21·19
New alfalfa	13 00						
Alfalfa seed		1,755	9·5*	3·32	25·0	48·0 *	16·80
Sweet clover	10 00	44	1·40t	14·00	53·0	2·60t	26·00
Sweet clover seed	0 06	249	34·20*	2·05			
Green feed	12 00						
Timothy	14 00	177	1·15t	16·10			
Grass hay	11 00	124	1·09t	11·99			
Pasture—							
Mixed grass		3,670		25·00			
Sweet clover seed							
Grains—							
Wheat	1 00	39,351	20·94b	20·94	16,632·0	19·69b	19·69
Winter wheat		512	17·14b	17·14			
Oats	0 50	7,140	31·06b	15·53	1,532·0	24·41b	12·20
Barley	0 56	4,596	29·98b	16·22	294·0	15·26b	8·54
Rye	0 90	506	11·40b	10·26			
Flax	2 00	114	8·04b	16·08	419·0	7·36b	14·72
Roots—							
Sugar beets	8 25	2	8·00t	66·00			
Potatoes	18 00	50	2·60t	46·80	51·0	3·02t	54·36
Cultivated—							
Corn stover							
Sunflowers							
Garden		242		60·00	40·1		60·00
Peas							
Other roots							
Miscellaneous		2,435		20·00			
Total Crop Area		75,184		19·92	21,052·0		19·40
Summer-fallow		14,302			2,858·0		
Unbroken land		60,624					
Idle land		33,332			1,145·0		
Total Arable Land		183,424			25,055·0		

Crop	Unit values	New West Irrigation District			Taber Irrigation District		
		Acres	Yield per acre	Value per acre	Acres	Yield per acre	Value per acre
	$			$			$
Forage—							
Alfalfa	13 00	96	1·07t	13·91	2,927	1·99t	25·87
New alfalfa	13 00						
Alfalfa seed							
Sweet clover	10 00	35					
Sweet clover seed	0 06						
Green feed	12 00	374	1·22t	12·20	312	1·13t	13·56
Timothy	14 00				116	1·16t	16·24
Grass hay	11 00				31	1·09t	11·99
Pasture—							
Mixed grass							
Sweet clover seed							
Grains—							
Wheat	1 00	3,818	18·20b	18·20	9,471	22·65b	22·65
Winter wheat					508	13·95b	13·95
Oats	0 50	116	28·85b	14·27	1,273	36·30b	18·15
Barley	0 56	249	15·87b	8·88	1,501	27·90b	15·62
Rye	0 90	100	6·00b	5·40	85	9·42b	8·48
Flax	2 00	10	1·00b	2·00	35	5·71b	11·42
Roots—							
Sugar beets	8 25				2,269	8·29t	68·39
Potatoes	18 00	9	2·00t	36·00	60	4·13t	74·34
Cultivated—							
Corn stover							
Sunflowers							
Garden					360		60·00
Peas							
Other roots							
Miscellaneous							
Total Crop Area		4,807		16·85	18,966		28·05
Summer-fallow					1,131		
Unbroken land					1,659		
Idle land		3,193			655		
Total Arable Land		8,000			22,411		

t=tons. b=bushels. *=pounds.

IRRIGATION PROJECTS NOT YET IN OPERATION

Little Bow Irrigation District

This project diverts water from the Highwood river on the NW. ¼ of section 6, township 19, range 28, west of the 4th meridian, near the town of High River. During the irrigation season, May 1, to September 30, some 849 acre-feet of water were diverted from the Highwood river into the Little Bow river. The maximum daily discharge during this period has been 6·7 cubic feet per second which occurred on several days during the months of May and June. The water has been used for domestic and stock-watering purposes only.

The bonded indebtedness of the district as at the close of the year was $26,000, the cost of management $466 and expenditure on repairs $140. There are 3,090 irrigable acres in the project, which are contingent upon the installation of pumping units for water-supply from the channel of the Little Bow river. As none of these plants have been installed no irrigation has been possible. The number of farmers using this diverted water for domestic and stock-watering purposes along the course of the Little Bow river is reported as 100.

Mountain View Irrigation District

Authorization for the construction of the necessary works for this project was issued on June 23, 1925. Plans for the major structures have been prepared and have now been filed with the Department. A right-of-way survey for that portion of Driggs Lake reservoir which lies on the NW. ¼ of section 11, township 2, range 28, west 4th meridian has been made and the plan filed. The works required to divert the water have not been constructed.

Alkali Test Plots at Maple Creek, Saskatchewan

These experimental plots have been carried on for 7 years to obtain some reliable data regarding the effect of irrigation on heavy soils with high alkali content. It is proposed to continue the experiments over a further period of three years. The growth of alfalfa in these plots continues to be heavy and as no evidence of alkali was noticed during the season it can reasonably be assumed that the movement of the injurious salts is downward. The successful production of alfalfa on these plots has induced two local farmers to undertake the development of a portion of the Maple Creek plots for the growth of alfalfa under irrigation.

Meteorological Data

The two following Plates 9 and 10 illustrate the average conditions in the central and semi-arid regions of Alberta respectively. Plate No. 9 shows that the natural precipitation is normally adequate to ensure average yields. Plate No. 10, however, again indicates that in a normal year the natural precipitation is insufficient to furnish the moisture required to produce an average crop. Both graphs cover a period of 45 years of record.

Farm Demonstration and Extension Work

Settlers on irrigated lands were assisted in laying out their farm laterals as in other years. Due to lack of rainfall in the early part of the season a heavy demand for engineering assistance and advice developed, particularly for ditch surveys. This demand was but temporary as the rainfall during the succeeding three months proved sufficient for crop needs.

Irrigation investigations were continued to determine the "Seasonal Use of Water by Sugar Beets" and "The Development of the Sugar Beet Root System." The results are given in detail under these headings in this report.

PLATE 9

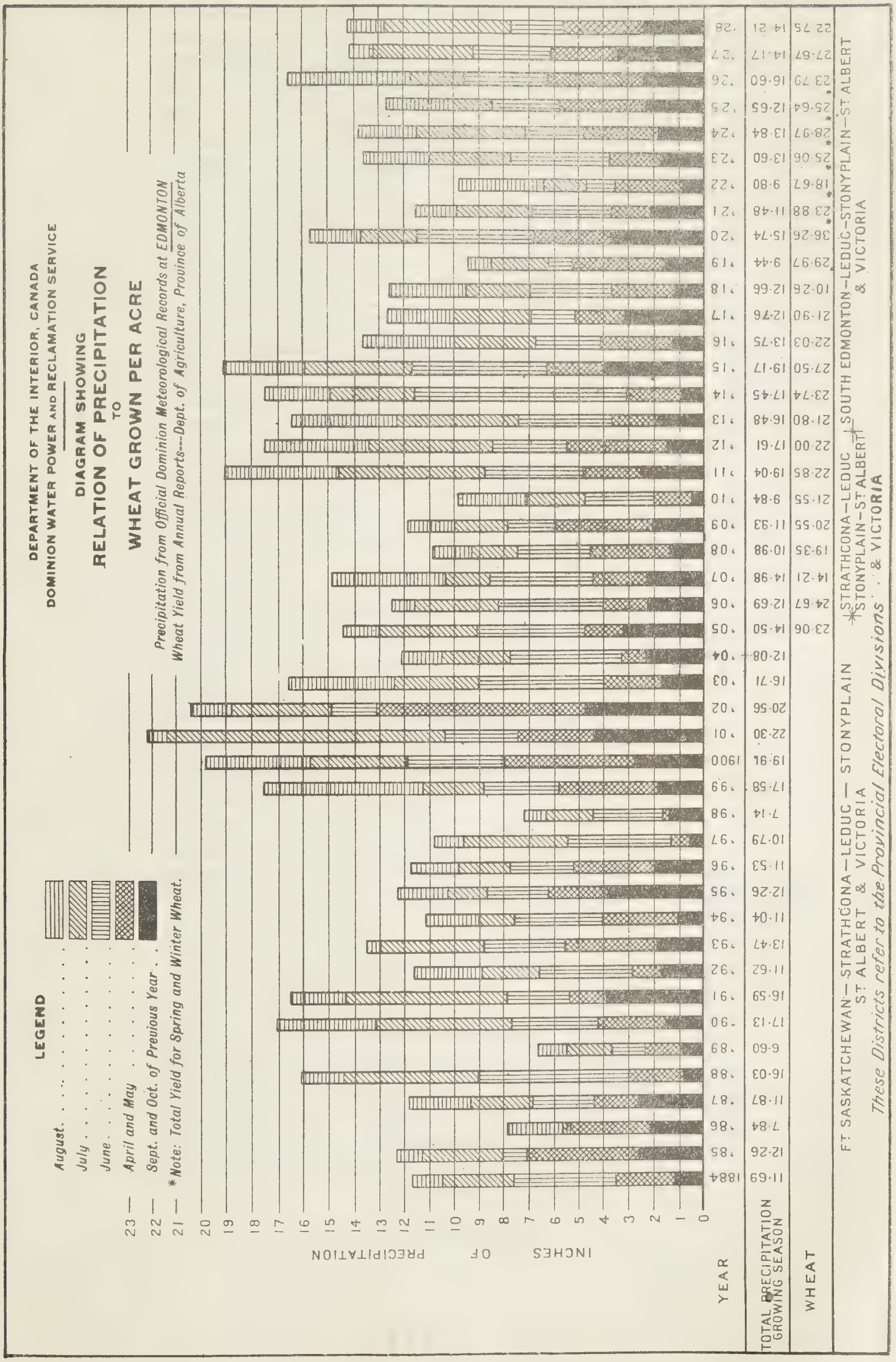
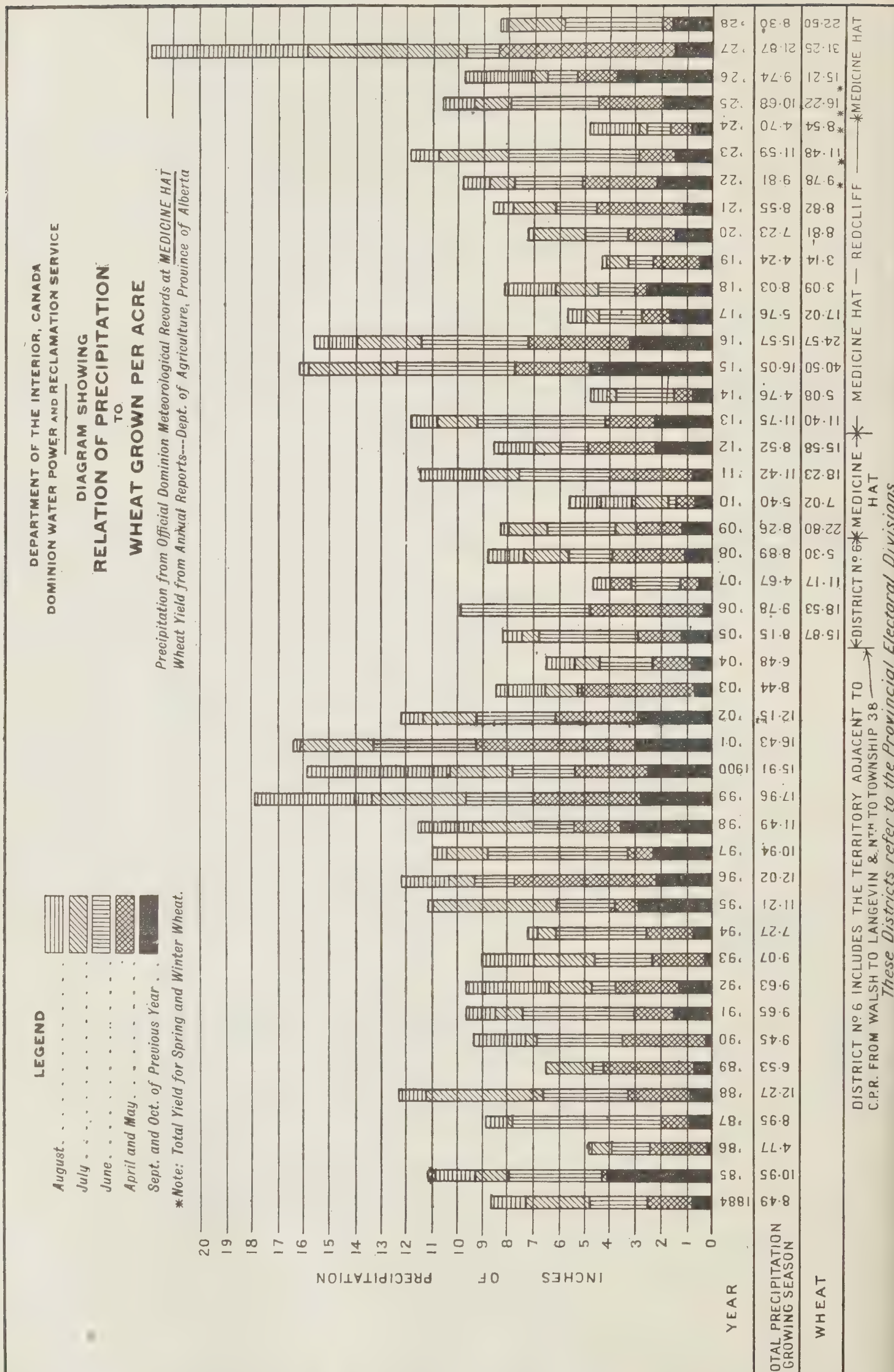

DEPARTMENT OF THE INTERIOR, CANADA
DOMINION WATER POWER AND RECLAMATION SERVICE
DIAGRAM SHOWING
RELATION OF PRECIPITATION
TO
WHEAT GROWN PER ACRE
Precipitation from Official Dominion Meteorological Records at EDMONTON
Wheat Yield from Annual Reports—Dept. of Agriculture, Province of Alberta
LEGEND
August
July
June
April and May
Sept. and Oct. of Previous Year
* Note: Total Yield for Spring and Winter Wheat.
INCHES OF PRECIPITATION
YEAR
TOTAL PRECIPITATION GROWING SEASON
WHEAT
1884 11·69
'85 12·26
'86 7·84
'87 11·87
'88 16·03
'89 6·60
'90 17·13
'91 16·59
'92 11·62
'93 13·47
'94 11·04
'95 12·26
'96 11·53
'97 10·79
'98 7·14
'99 17·58
1900 19·91
'01 22·30
'02 20·56
'03 16·71
'04 12·08
'05 14·50 23·06
'06 12·69 24·67
'07 14·98 14·21
'08 10·98 19·35
'09 11·93 20·55
'10 9·84 21·55
'11 19·04 22·85
'12 17·61 22·00
'13 16·48 21·80
'14 17·45 23·74
'15 19·17 27·50
'16 13·75 22·03
'17 12·76 21·90
'18 12·66 10·26
'19 9·44 29·97
'20 15·74 36·26
'21 11·48 23·88
'22 9·80 18·67
'23 13·60 25·06
'24 13·84 28·97
'25 12·65 25·64
'26 16·60 23·79
'27 14·17 27·67
'28 14·21 22·75
FT SASKATCHEWAN—STRATHCONA—LEDUC — STONYPLAIN
ST ALBERT & VICTORIA
STRATHCONA—LEDUC
STONYPLAIN—ST ALBERT
& VICTORIA
SOUTH EDMONTON—LEDUC—STONYPLAIN—ST ALBERT
& VICTORIA
These Districts refer to the Provincial Electoral Divisions

PLATE 10


DEPARTMENT OF THE INTERIOR, CANADA
DOMINION WATER POWER AND RECLAMATION SERVICE
DIAGRAM SHOWING
RELATION OF PRECIPITATION
TO
WHEAT GROWN PER ACRE
Precipitation from Official Dominion Meteorological Records at MEDICINE HAT
Wheat Yield from Annual Reports---Dept. of Agriculture, Province of Alberta
LEGEND
August
July
June
April and May
Sept. and Oct. of Previous Year
*Note: Total Yield for Spring and Winter Wheat.
INCHES OF PRECIPITATION
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
YEAR
1884 '85 '86 '87 '88 '89 '90 '91 '92 '93 '94 '95 '96 '97 '98 '99 1900 '01 '02 '03 '04 '05 '06 '07 '08 '09 '10 '11 '12 '13 '14 '15 '16 '17 '18 '19 '20 '21 '22 '23 '24 '25 '26 '27 '28
TOTAL PRECIPITATION GROWING SEASON
8·49 10·95 4·77 8·95 12·27 6·53 9·45 9·65 9·63 9·07 7·27 11·21 12·02 10·94 11·49 17·96 15·91 16·43 12·15 8·44 6·48 8·15 9·78 4·67 8·89 8·26 5·40 11·42 8·52 11·75 4·76 16·05 15·57 5·76 8·03 4·24 7·23 8·55 9·81 11·59 4·70 10·68 9·74 21·87 8·30
WHEAT
15·87 18·53 11·17 5·30 22·80 7·02 18·23 15·58 11·40 5·08 40·50 24·57 17·02 3·09 3·14 8·81 8·82 9·78* 11·48* 8·54* 16·22* 15·21* 31·25 22·50
DISTRICT Nº 6 INCLUDES THE TERRITORY ADJACENT TO C.P.R. FROM WALSH TO LANGEVIN & Nᵀᴴ TO TOWNSHIP 38
DISTRICT Nº 6 MEDICINE HAT
MEDICINE HAT
MEDICINE HAT — REDCLIFF
MEDICINE HAT
These Districts refer to the Provincial Electoral Divisions

Brooks Duty of Water Experiment Station

METEOROLOGY

The weather during 1928 showed some unusual features in respect to precipitation and temperature. During the first five months of the year less than 1·50 inches of moisture fell and by the end of May extreme drought prevailed. The situation was made more acute by high winds from the southwest and by high temperatures. Conditions, therefore, were not favourable for seed germination or early growth. Irrigation was needed to some extent for germination purposes as the drought did not end until June 3. Rainy weather set in at that date and continued quite regularly throughout June and July. Moisture requirements were then adequately supplied by rainfall and crops generally made excellent growth during this period. Unfortunately growing conditions during the later part of the season were not so favourable in that relatively low temperatures prevailed. Maturity was in many cases retarded by the cool weather following the heat wave early in August.

Table No. 1.—Summary Meteorological Data, April to October (inclusive) 1928, Brooks, Alberta

Month	Temperature Data °F.							Precipitation (inches)			Evaporation (inches) Face Water Surface 4′ diam.				Wind	
	Maximum recorded	Minimum recorded	Mean Maximum	Mean Minimum	Mean	Departure of mean from average (1915-26)		Total	Departure from average (1915-26)		Total from tank in exposed location	Total from tank in sheltered location	Departure from average 1918-26 (sheltered tank)		Maximum velocity recorded	Average hourly velocity
						+	−		+	−			+	−		
April	82·0	11·0	52·1	24·7	38·4	......	4·0	0·42	......	0·46	......	1·89	......	0·98	43	9·6
May	94·0	21·0	75·7	40·4	58·1	6·7	......	0·09	......	0·86	7·90	4·89	......	0·33	41	8·5
June	82·0	36·0	70·1	45·5	57·8	......	2·8	4·53	2·58	......	5·06	3·10	......	2·28	27	6·9
July	90·0	43·0	77·6	52·3	65·0	......	1·8	3·62	2·14	......	5·50	3·70	......	2·46	28	6·7
August	94·0	34·0	75·9	45·9	60·9	......	3·3	0·16	......	1·49	4·63	2·91	......	1·89	27	5·4
September	87·0	18·0	70·1	35·6	52·8	......	0·9	0·10	......	1·20	4·40	2·69	......	0·58	30	6·9
October	71·0	14·0	51·6	27·4	39·5	......	0·5	0·48	......	......	2·10	1·52	......	......	32	8·7
Net totals and averages—																
April-October inclusive			67·6	38·8	53·2	......	0·9	9·40	0·71	......	......	20·70	......	8·52	32	7·5
May-August inclusive			74·8	46·0	60·4	......	0·3	8·40	2·37	......	23·03	14·60	......	6·96	31	6·9

Last spring frost 32°, recorded May 10. First fall frost 22°, recorded September 8. Frost free period=121 days. Last spring killing frost, 24°, recorded May 4. First fall killing frost 22°, recorded September 8. Killing frost free period=127 days.

Some interesting evaporation data were obtained. The old pan in use at the station, originally situated in an exposed position, has in recent years become increasingly sheltered by adjacent tree growth and during this time evaporation losses have shown a steady decrease annually which is attributed to the protective influence of the trees. To determine the exent of this influence a new pan was set out in a thoroughly exposed location, where the water surface received full effect of any prevailing wind. Comparing the results during the four months, May to August, the average evaporation losses from the fully exposed pan were 57·7 per cent greater than the losses from the one partly sheltered.

There was no precipitation of any consequence during the last three months of the season and conditions were exceedingly favourable for harvesting and threshing, though the soil was too dry for good fall ploughing. A summary of the meteorological data recorded April to October, inclusive, and departures from averages are shown in table 1.

INVESTIGATIONS 1928

Some new lines of work were undertaken during 1928 including (1) time of irrigation and time of use of water, (2) irrigation of soil improvement crops, (3) use of super-phosphate fertilizer under irrigation, and (4) the irrigation requirements of fall wheat. Studies in connection with the water requirements of sugar beets were continued, and a limited amount of work was carried on with alfalfa seed and several varieties of beans. A limited amount of co-operative work was done for the Dominion Seed Branch in connection with the study of impermeable seed in Sweet Clover. The main investigations are hereafter briefly outlined and the 1928 results reported and summarized.

Time of Irrigation and Use of Water

The main purpose of this investigation is to determine as nearly as possible at what stage or stages of crop growth to irrigate in order to obtain maximum yield and quality with the least amount of irrigation. Time of use is determined from observations made throughout the season, including soil moisture tests, precipitation and irrigations applied. The use as determined represents the field use of water and includes the amount of water lost by deep percolation, run-off, evaporation from the soil, and transpiration from the growing crop.

Time of application is studied in relation to (1) fertility as affected by crop rotation, (2) number of irrigations including one and two applications and, (3) the moisture content of the soil. Four crop rotations are used.

Rotation I (4 years), Barley, Sweet Clover hay, sugar beets and wheat. The barley is used as a nurse crop for the Sweet Clover.

Rotation II (8 years), Barley, Alfalfa Hay, 3 years, sugar beets, wheat and oats. The barley is used as a nurse crop for the alfalfa.

Rotation III (4 years), Sugar beets, wheat, oats and barley.

Rotation IV (4 years), wheat, Sweet Clover hay, potatoes and sugar beets. The wheat is used as a nurse crop for the Sweet Clover.

Separate irrigation schedules are planned for each crop. The cereals for example are irrigated at the three leaf, shot blade, boot and flower stages and in a similar way the root and hay crops are irrigated at different stages of development. Fall irrigations are to constitute an important part of the investigation.

The depth of each irrigation applied is regulated according to the moisture content of the soil as determined from soil samples collected previous to the time of application and is based on a total moisture holding capacity of from 14·5 to 16·0 inches to 4 feet of soil. If the moisture content for example amounts to 12 inches, a 4-inch irrigation is applied and a 6-inch irrigation is applied when the soil shows only 10 inches. No irrigation lighter than 2 inches is attempted.

Results—Time of Irrigation Experiments

The work in connection with this project in 1928 was largely preliminary. Two or three years at least will be required for the rotations to become effective and the plots adjusted to the new irrigation schedules being followed. Furthermore weather conditions during the season were not favourable for irrigation experiments. With the heavy rainfall during June and July there was little or no control over moisture during the critical periods of growth and mostly negative results were obtained. The cereal, sugar beet and corn results are discussed separately as follows:

Cereals.—With the single exception of oats none of the cereals showed any benefit from irrigation, and even in case of the oat crop the results are not outstanding. There was barely enough moisture in the soil for germination, but

after the rains started in June, moisture requirements of crops were so nearly supplied by natural means that any irrigations applied disturbed rather than benefited growth. In this connection it is interesting to note that barley proved most sensitive to over-irrigation and oats the most tolerant. And further, that while nearly all irrigations applied resulted in decreased yields, these depressions were least where irrigations were applied either during the three leaf or flower stages due no doubt to the lack of rainfall during these two periods. A summary of results is given in Table 2.

Table No. 2.—Summary of Yields, Irrigations and Soil Moisture Data from Wheat, Oats and Barley time of Irrigation Studies

Crop	Stage of Growth Irrigation Applied	Moisture Data (inches)							Yield per acre (bush.)
		Irrigations applied	Total received irrigation and rainfall	Distribution of Use				Total used	
				May	June	July	Aug.		
Wheat	Nil	0·0	8·2	1·4	3·0	3·6	2·2	10·2	35·2
	3 leaf	6·0	14·2	4·1	5·7	3·3	2·0	15·1	31·9
Ranges 1 and 11	Shot blade	6·0	14·2	1·1	7·8	3·0	1·8	13·7	29·1
	Flower	2·0	10·2	0·9	4·3	3·5	2·4	11·1	33·1
	3 leaf and shot blade	12·0	20·2	4·4	11·5	3·6	2·2	21·7	26·6
	3 leaf and flower	8·0	16·2	4·4	6·0	5·1	2·8	18·4	29·4
	Shot blade and flower	6·0	14·2	1·6	6·0	6·0	2·4	16·0	32·6
Oats	Nil	0·0	8·2	0·6	2·8	3·1	1·6	8·1	62·3
	3 leaf	6·0	14·2	3·2	6·6	3·0	1·3	14·1	57·5
Ranges 5 and 10	Shot blade	6·0	14·2	1·1	7·2	5·6	1·9	15·8	53·6
	Flower	2·5	10·7	0·4	3·0	4·3	2·3	10·1	60·1
	3 leaf and shot blade	12·0	20·2	3·0	9·8	5·1	1·8	19·7	66·8
	3 leaf and flower	...	...	...	...	...	...	...	...
	Shot blade and flower	7·8	16·0	2·7	7·3	4·6	3·6	17·5	55·0
Barley	Nil	0·0	8·2	...	4·2	3·2	1·3	8·7	42·6
	3 leaf	6·0	14·2	...	7·9	5·9	1·9	15·7	41·9
	Shot blade	4·0	12·2	...	6·2	4·1	1·4	11·7	38·4
Ranges 4 and 9	Flower	2·8	11·0	...	3·5	4·8	2·8	11·1	39·9
	3 leaf and shot blade	10·0	18·2	...	12·0	5·4	1·8	19·2	26·1
	3 leaf and flower	9·5	17·7	...	8·4	6·7	3·0	18·1	38·0
	Shot blade and flower	7·5	15·7	...	6·3	6·5	3·4	16·2	38·3

The extremely low use of water by all of the cereal crops is an outstanding feature of the 1928 results. Maximum yields of wheat and barley were obtained with average moisture uses of only 10·2 and 8·7 inches respectively, while over 93 per cent of the maximum yield of oats was obtained with a moisture use of 8·1 inches. Favourable distribution of rainfall and low evaporation losses account for this exceptional efficiency. The relatively low maximum yields obtained are attributable to low fertility. Higher yields from the plots used are not to be expected until the present rotations become effective.

Time of Irrigation of Sugar Beets

Only a limited amount of data were obtained on the time of irrigation of sugar beets largely on account of the rainfall and variability in soil conditions persisting from the duty of water experiments formerly conducted in the area. The moisture data showing the monthly use in inches comprise the main results obtained and are summarized in table 3. Details of irrigations applied, moisture used, and yields obtained are shown. Following are the average monthly moisture uses on all of the plots under observation: May, 4·48 inches; June, 4·85; July, 3·40; August, 2·18; September, 1·78; and October, 0·98 inch; making a total average seasonal use of 17·6 inches. Irrigation was needed in May for seed germination and early growth, but in June and July moisture requirements were entirely supplied by rainfall and no further irrigations were needed until August. In the water requirement experiments using two irrigations in addition to the spring application these proved most useful

when applied late in July and during the heat wave early in August, whereas one application in the time of irrigation experiments proved most effective when applied later in August.

Table 3.—Time of Irrigation and Monthly Use of Water—Sugar Beets

Plot No.	Moisture Data (inches)														Yield per acre	
	Irrigations applied and Distribution of Use												Totals		Tons of Beets	Pounds of Sugar
	May		June		July		Aug.		Sept.		Oct.					
	Irrigation	Used	Irrigation	Used	Irrigation	Used	Irrigation	Used	Irrigation	Used	Irrigation	Used	Irrigation	Used		
	(28th)				(28th)											
2G	4·0	3·4		3·9	3·0	4·4		2·2		2·1		1·2		17·0	8·65	2,440
2K	4·0	4·6		4·7	2·0	3·6		1·1		1·1		0·6		15·7	8·70	2,040
15G	4·0	4·5		4·7	2·5	2·9		2·9		2·8		1·6		19·4	12·10	2,860
15K	4·0	3·4		3·7	5·0	3·1		2·9		2·8		1·5		17·4	5·48	1,400
Averages	4·0	4·0		4·2	3·1	3·5		2·3		2·2		1·2	11·3	17·4	8·73	2,195
	(28th)						(11th)									
2B	4·0	5·2		5·8		3·2	0·0	0·7		0·1		0·4		15·4	10·70	3,100
2H	4·0	4·1		4·6		3·8	5·0	3·3		3·2		1·6		20·6	10·18	2,190
15B	4·0	4·8		5·4		3·5	0·0	1·7		1·5		0·8		17·7	8·42	2,060
15H	4·0	4·6		4·9		3·3	5·0	3·5		3·4		2·0		21·7	5·90	1,510
Averages	4·0	4·7		5·1		3·5	2·5	2·3		2·1		1·2	6·5	18·9	8·80	2,220
	(30th)						(27th)									
2C	4·0	5·0		5·6		4·1	2·0	2·7		1·1		0·5		19·0	12·0	3,850
2E	4·0	4·4		4·8		3·7	3·0	2·9		1·8		1·2		18·8	9·6	3,170
15C	4·0	4·9		5·5		3·3	0·0	1·8		1·7		0·9		18·1	9·0	2,100
15E	4·0	4·8		5·2		4·0	4·0	2·8		0·3		0·1		17·2	11·4	2,200
Averages	4·0	4·8		5·3		3·8	2·2	2·6		1·3		0·7	6·2	18·5	10·5	2,830
	(30th)															
2D	4·0	5·2		5·8		2·5		1·3		1·2		0·6		16·6	10·10	3,720
2F	4·0	4·7		5·4		2·7		1·3		1·2		0·7		16·0	8·35	1,970
2J	4·0	3·1		3·4		2·4		1·8		1·7		0·9		13·3	6·85	1,480
15D	4·0	4·5		4·7		2·7		1·4		1·3		0·9		15·5	10·15	2,630
15F	4·0	4·9		5·2		3·4		2·1		2·0		0·5		18·1	8·35	2,340
15J	4·0	3·9		4·3		2·7		1·8		1·7		0·9		15·3	5·72	1,530
Averages	4·0	4·4		4·8		2·8		1·5		1·5		0·8	4·0	15·8	8·25	2,280

Corn.—The season was not a favourable one for corn. Growth was somewhat retarded during the rainy weather in June and cool temperatures late in August so that the crop was not sufficiently advanced to escape serious injury from the killing frost on September 8. The maximum yield of 5·90 tons stover per acre was obtained with one 3-inch irrigation applied August 6. Lower yields were obtained from one or two irrigations applied either earlier or later, while the average yield from the dry land plots was 3·74 tons. The corn plots were seeded May 17 in rows 36 inches apart. Gehu is the variety used.

Hay and Potatoes.—No experimental results were obtained from any of the hay series since these were all seeded this year. The maximum yield of 253 bushels of potatoes was obtained without irrigation where the soil showed a relatively high moisture content early in the season; and the plots giving the highest yields showed an average seasonal use of 8·5 inches. Russet Burbank is the variety of potatoes used.

Fall Irrigation

Four plots in each series, excepting sugar beets and potatoes, were fall irrigated for next year's work. Conditions were exceptionally dry and the

irrigation water applied during the last of September, was readily absorbed by the soil. Six inches of irrigation were required to bring the moisture content of most of the plots up to full holding capacity. Considerable benefit may be expected from these irrigations next year.

Irrigation of Soil-Improvement Crops

This investigation is to be a comparative study of soil improvement crops in relation to irrigation. Sweet clover, red clover and alfalfa are included and summer-fallow is used as a check. The crops were seeded in May and fairly uniform stands were obtained. The plots are to be ploughed up in 1929 and seeded to wheat. A new area of land was broken up for the continuation of the work in 1929.

Water Requirements of Sugar Beets

The water-requirement sugar beet experiments were conducted under somewhat adverse conditions. Owing to change of plans spring-ploughed land had to be used and with extreme drought prevailing during May favourable soil moisture conditions were exceedingly difficult to maintain. Irrigation was applied to all the plots late in May for germination purposes and this proved helpful. Uneven stands were obtained for the most part however and early growth was seemingly slow. Growing conditions were more favourable during the remainder of the season but the crop never fully recovered.

The experiments consisted of 8 series of plots, including alfalfa, clover, and non-legume rotations. Irrigations applied varied from one to four applications. Table 4 gives the details of results. The yields shown are corrected for stand and in some cases are considerably higher than the yields per acre actually obtained. These corrections are necessary, however, to show more fully the effect of irrigations applied and indicate more accurately true relative differences. Sugar beets were benefited considerably by irrigation as already shown in the time of irrigation results. In addition to the irrigation applied in May for seed germination increased yields were obtained with one, and in some cases two irrigations applied after the rainy weather in June and July. The results from different irrigations are summarized in Table 5.

Table 4—Sugar Beet Results—Water Requirement Experiment

Rotation	Plot No.	Date Irrigations Applied and Depth in Inches				Moisture Data Inches			Yields Corrected for stand		
						Irrigation applied	Total Irrigation and rainfall	Total used per acre	Tons of Beets per acre	Per cent Sugar	Pounds Sugar per acre
5th yr. after alfalfa		May 25 inches	July 25 inches	Aug. 10 inches	Aug. 25 inches	inches	inches	inches			
	44A.....	3	....	....	....	3	11·3	13·9	10·6	15·7	2,580
	44B.....	3	4	4	....	7	15·3	19·5	12·7	14·9	2,920
	C.....	3	....	4	....	11	19·3	25·9	11·0	16·4	3,160
	D....	3	....	4	4	11	19·3	21·7	10·6	14·9	2,480
	E.....	3	3	4	4	14	22·3	25·2	7·3	15·4	1,770
	Ave.....	....	....	....	....	....	....	21·2	10·4	15·5	2,580
4th yr. after alfalfa		May 23	July 24	Aug. 11	Aug. 25						
	46 A.....	3	....	....	....	3	11·3	10·5	10·65	17·8	3,180
	B.....	3	....	4	....	7	15·3	16·7	13·10	15·8	3,140
	C.....	3	4	4	....	11	19·3	20·8	10·60	....	....
	D....	3	....	4	4	11	19·3	18·8	11·96	17·3	3,430
	E.....	3	3	4	4	14	32·3	28·3	7·23	16·0	1,870
	Ave.....	....	....	....	....	....	....	19·0	10·70	16·7	2,905
3rd yr. after alfalfa		May 19	July 25	Aug. 10	Aug. 27						
	48 A.....	3	....	....	....	3	11·3	12·5	10·97	19·2	3,460
	B.....	3	....	4	....	7	15·3	15·6	11·05	17·4	2,980
	C.....	3	4	4	....	11	19·3	20·8	12·04	18·9	3,640
	D.....	3	....	4	4	11	19·3	18·8	13·21	16·7	3,460
	E.....	3	3	4	4	14	22·3	28·3	10·41	18·5	3,210
	Ave.....	....	....	....	....	....	....	19·2	11·53	18·1	3,350
2nd yr. after alfalfa		May 19	July 25	Aug. 11	Aug. 27						
	52 A.....	3	....	....	....	3	11·3	10·6	7·46	....	....
	B.....	3	....	4	....	7	15·3	16·2	13·10	17·0	3,640
	C.....	3	3	4	....	10	18·3	25·2	10·52	17·3	2,850
	53 A.....	3	4	4	4	15	23·3	23·6	13·49	16·3	3,480
	B.....	3	....	4	4	11	19·3	20·2	14·50	18·5	4,510
	C.....	3	....	....	....	3	11·3	9·6	11·07	16·5	2,940
	Ave.....	....	....	....	....	....	....	17·6	11·69	17·1	3,484
1st yr. after alfalfa		May 25	July 25	Aug. 11	Aug. 27						
	54 A.....	3	....	4	....	7	15·2	18·1	11·92	18·6	3,700
	B.....	3	....	4	....	7	15·2	21·3	18·45	18·1	5,530
	C.....	3	3	4	....	10	18·2	20·4	17·20	17·1	4,780
	D....	3	....	4	4	11	19·2	20·2	12·97	16·7	3,520
	E.....	3	3	4	4	14	22·2	22·7	8·30	15·8	2,060
	Ave.....	....	....	....	....	....	....	20·5	13·77	17·2	3,918
1st yr. after clover		May 25	July 26	Aug 11	Aug. 27						
	60 A...	....	....	..	....	0	8·2	7·8	5·65	17·0	1,590
	B.....	(June 2) 3	....	4	....	7	15·2	18·3	10·93	17·5	3,120
	C.....	3	4	4	....	11	19·2	18·8	12·34	18·2	3,760
	D....	3	....	4	4	11	19·2	23·4	10·20	17·3	2,930
	E.....	3	3	4	4	14	22·2	26·3	13·54	16·2	3,550
	Ave.....	....	....	....	....	....	....	18·9	10·53	17·2	2,990
2nd yr. after clover		May 21	July 26	Aug. 11	Aug. 27						
	70 A.....	4	....	....	....	4	12·3	15·6	15·60	14·7	2,900
	B.....	4	....	4	....	8	16·3	21·4	15·25	13·2	2,880
	C.....	4	3	4	....	11	19·3	25·1	18·30	15·7	4,350
	D....	4	....	4	4	12	20·3	23·0	13·82	17·5	4,000
	E.....	4	3	4	4	15	23·3	30·7	11·15	17·5	3,230
	Ave.....	....	....	....	....	....	....	23·1	14·82	15·7	3,472
4th yr. after grass		May 19	July 25	Aug. 11	Aug. 27						
	89-90A. .	3	....	....	....	3	11·3	11·0	6·41	16·6	1,760
	B.....	3	....	4	....	7	15·3	18·5	9·83	18·4	3,160
	C.....	3	3	4	....	10	18·3	22·4	12·10	17·8	2,980
	D....	3	....	4	4	11	19·3	22·4	11·03	16·7	3,050
	E.....	3	3	4	4	14	22·3	22·8	11·20	16·7	3,050
	Ave.....	....	....	....	....	....	....	19·4	10·11	17·4	2,190

Table 5.—Summary of Sugar Beet Yields from Different Amounts of Irrigation

Irrigations applied		Yield per acre				Per cent sugar in beets	Average inches water used	Pounds sugar per inches water used
No.	Inches	Tons Beets		Pounds Sugar				
		Maximum	Average	Maximum	Average			
1	3·0	15·60	10·23	3,460	2,803	16·8	12·2	230
2	7·0	18·45	13·05	5,530	3,420	16·5	18·4	186
3	10·6	18·30	13·01	4,780	3,640	17·3	22·4	162
3	11·0	14·50	12·28	4,510	3,420	16·9	21·1	162
4	14·0	13·54	10·33	3,550	2,740	16·5	25·9	106

Yields from the different rotations are summarized in Table 6. Maximum and average yields of beets and sugar and average depths of water used are shown. In the legume rotations maximum yields were obtained following the first year after alfalfa and the second year after clover. This is quite different from last year when the highest yields were obtained the fourth year after alfalfa and the first year after clover. The rather exceptional weather probably accounts for the results this year.

Table 6.—Sugar Beet Yields Following Different Crops

Series	Place of Beets in Rotation	Yield of Beets per acre		Yield of Sugar pounds per acre			Average depth water used
		Max.	Ave.	Ave. %	Max.	Ave.	
44	5th year after alfalfa	12·70	10·40	15·5	3,160	2,580	21·2
46	4th year after alfalfa	13·10	10·71	16·7	3,430	2,905	19·0
48	3rd year after alfalfa	13·21	11·53	18·1	3,640	3,350	19·2
52-53	2nd year after alfalfa	14·50	11·69	17·1	4,510	3,484	17·6
54	1st year after alfafa	18·45	13·77	17·2	5,530	3,918	20·5
60	1st year after clover	13·54	10·53	17·2	3,760	2,990	18·9
70	2nd year after clover	18·30	14·82	15·7	4,350	3,472	23·1
89-90	4th year after grass	12·10	10·11	17·4	3,160	2,190	19·4

Beans and Alfalfa Seed.—Nothing of a conclusive nature was obtained regarding the irrigation requirements of either of these two crops during 1928 since the moisture needed was more than supplied by rainfall. The maturity of the bean crop was retarded by cool temperatures and the heavy rains during June and July proved disastrous to the alfalfa seed crop. The small number of pods that finally set were largely destroyed by a heavy infestation of the Bertha Army cutworm.

Super-Phosphate Fertilizer Investigation

What promises to become an interesting, as well as important, study was undertaken during the year in connection with the use of a super-phosphate fertilizer that is being tried out by a number of experiment stations and farmers in Alberta, Saskatchewan and Manitoba. The work at Brooks is devoted mainly to the study of the agricultural value of the fertilizer under irrigation. In the 1928 experiments wheat was grown with and without the fertilizer on one series of plots in a non-legume rotation and two series following the second and third years after clover. One and two irrigations were applied and at different stages of growth, including 3-leaf, shot blade and flower. A more extensive irrigation schedule was planned but was curtailed on account of the heavy rainfall. Details of irrigations applied and results obtained are given in table 7.

Table No. 7.—Super-phosphate Tests with Marquis Wheat under Irrigation applied rate of 50 pounds per acre

Rotation.	Plot No.	Moisture data (inches): Stages of growth irrigations applied	Moisture data (inches): Total depth irrigation applied	Moisture data (inches): Total Depth irrigation and rain	Results: Not treated: Date wheat matured	Results: Not treated: Yield per acre	Results: Not treated: Grade of wheat	Results: Treated with Super-phosphate: Date wheat matured	Results: Treated with Super-phosphate: Yield per acre	Results: Treated with Super-phosphate: Grade of wheat	Results: Summary: No. of days maturity advanced	Results: Summary: Increase in yield (bush. per acre)	Results: Summary: Spread in grade
After grain—No legume	83A	Nil............	0·0	8·2	Aug. 22	....	2 Nor.	Aug. 17	....	1 Nor.	3	....	1
	83B	Shot blade.....	6·0	14·2	" 24	26·8	3 "	" 18	31·2	2 "	6	+4·4	1
	83C	3-leaf...........	6·0	14·2	" 24	26·5	2 "	" 18	32·6	2 "	6	+6·1	0
	83D	3 leaf and flower	10·0	18·2	" 24	....	2 "	" 18	....	....	6	....	....
	83E	Nil............	0·0	8·2	" 22	27·5	2 "	" 18	27·4	1 "	4	−0·1	1
	84A	Flower.........	4·0	12·2	" 24	26·2	2 "	" 18	21·4	2 "	6	−4·8	0
	84B	Nil............	0·0	8·2	" 19	21·3	1 "	" 17	19·3	1 "	2	−2·0	0
	84C	3-leaf...........	6·0	14·2	" 21	24·2	2 "	" 18	31·7	2	3	+7·5	0
	84D	Shot blade.....	6·0	14·2	" 22	25·2	2 "	" 18	26·0	2	4	+0·8	0
	84E	Nil............	0·0	8·2	" 21	24·2	....	" 18	28·0	....	3	+3·8	....
		Averages.......	....	....	....	25·2	2·0	....	27·2	1·6	4·3	+2·0	+0·3
3 years after clover	66A	Nil............	0·0	8·2	Aug. 25	28·2	2 Nor	Aug. 16	31·1	2 Nor.	9	+2·9	0
	66B	Shot blade.....	4·0	12·2	" 26	33·0	3 "	" 18	35·0	1 "	8	+2·0	2
	66C	3-leaf...........	6·0	14·2	" 27	35·6	3 "	" 18	34·6	1 "	9	−1·0	2
	66D	3 leaf and flower	10·0	18·2	" 27	34·2	3 "	" 19	35·7	2 "	8	+1·5	1
	66E	Nil............	0·0	8·2	" 22	35·2	2 "	" 18	38·4	2 "	4	+3·2	0
	67A	Flower.........	4·0	12·2	" 27	35·6	2 "	" 20	39·2	1 "	7	+3·6	1
	67B	Nil............	0·0	8·2	" 27	35·8	3 "	" 22	43·6	1 "	5	+7·8	2
	67C	3-leaf...........	6·0	14·2	" 27	35·8	3 "	" 23	42·4	2 "	4	+6·6	1
	67D	Shot blade.....	4·0	12·2	" 27	41·9	3 "	" 20	44·7	2 "	7	+2·8	1
	67E	Nil............	0·0	8·2	" 27	41·7	....	" 19	41·8	....	8	+0·1	....
		Averages.......	....	....	....	35·7	2·4	....	38·6	1·4	6·9	+2·9	+1·0
2 yr. after clov.	68A	Nil............	0·0	8·2	Aug. 28	53·0	3 Nor.	Aug. 25	53·7	2 Nor.	3	+0·7	1
	68B	Shot blade.....	4·0	12·2	" 30	46·5	....	" 22	47·7	....	8	+1·2	....
	68C	3-leaf...........	6·0	14·2	" 27	53·5	2 Nor.	" 22	53·6	2 Nor.	5	+0·1	0
	68D	3 leaf and flower	10·0	18·2	" 30	41·5	4 "	" 27	46·8	3 "	7	+5·3	1
	68E	Nil............	0·0	8·2	" 28	40·8	3 "	" 22	48·8	2 "	6	+8·0	1
		Averages.....	....	....	....	47·1	3·0	....	50·1	2·25	5·8	+3·6	+0·75

Quite definite results, it will be noted, were obtained from the application of the super-phosphate in plots in the legume rotations, where a good supply of soluble nitrogen was probably available and an abundance of active organic matter present. Under the conditions the wheat tillered more heavily, matured about a week earlier, yielded averages of 2·9 and 3·6 bushels more per acre and with only three exceptions graded one and two grades higher than wheat on the untreated areas. In the non-legume rotation, where organic matter content would naturally be lower and available nitrogen less abundant, the phosphate proved less beneficial. Here increase in tillering was less marked, there was less advancement in maturity, less increase in yield and less difference in grade. In fact on a few of these plots the application of super-phosphate apparently reduced yields. Growth was unduly forced probably in the absence of adequate soluble nitrogen.

Owing to the heavy rainfall during June and July, the results show very little effect from irrigation. An examination of the data does indicate, however, that the fertilizer was most effective, where a fairly abundant supply of moisture was present in soil early in the season.

EXTENSION WORK

A considerable amount of extension work was carried on in connection with the operation of the station during 1928. A field day, sponsored by the local farmer organization was held early in August and attended by nearly 500 people. In addition there were over 300 visitors at the station during other times of the season. Members of the staff assisted with the boys' and girls' garden and sugar beet clubs organized in connection with the local school fair. It is worthy of note that increased interest in the work of the station is displayed by irrigation farmers generally.

FIELD OBSERVATIONS ON THE DEVELOPMENT OF THE SUGAR BEET ROOT SYSTEM, 1928

Field observations on the development of the root system of sugar beets, as influenced by soil fertility, soil texture and soil moisture, were continued during the growing season of 1928 along much the same lines as those followed in 1927.

Plate 11.—Beets on heavy clay soil at Hillspring, Alta., Elevation 3,800.

The development of the beet-root system on the heavy clay soil at Hillspring was similar to that observed in 1927. Conditions during June, 1928, were more favourable for root growth than during June, 1927. Plate 11 shows the root development at Hillspring on four different dates during the growing season. This field was too wet until September.

By August 11, the beets had developed tap-roots to a depth of 22 inches with few and scanty branches beyond a depth of 10 inches below the surface, but with an abnormal development of long heavy branches feeding in 8 or 10 inches of the surface soil. On September 22, the tap-roots had attained a length of 32 inches with long heavy branches extending to lengths of 24 inches in the surface foot of soil. On September 22, the average length of tap-root at Welling was 48 inches and at Tabor 50 inches. This soil is a very heavy clay and was very wet all season. Roots cannot grow without air and warmth, so only about 10 per cent of the root development in this field occurred below the surface foot of soil.

Plate 12.—Beets, on clay loam soil that was much too dry in May and August, Welling, Alta.

The drawings on Plate 12 show the seasonal growth of the root system of sugar beets in a well drained clay loam soil at the C. D. Peterson farm near Welling. The growth of these beets may be considered as somewhat abnormal as the soil is not very fertile. It has been cropped many years without the introduction of organic matter in the form of legumes or manures. The surface soil was quite moist during June and July. This condition was favourable to an extensive root development in the surface foot of soil. On July 11, the tap-root was down 22 inches, and numerous lateral branches up to 10 inches in length filled the surface foot of soil. On August 6, the tap-root was down to a depth of 42 inches, with lateral roots not very numerous but distributed quite uniformly throughout the entire depth. The surface soil had dried out and baked hard to a depth of from 4 to 6 inches. Nearly all the roots in this baked and dried portion had dried up and ceased to function. On September 30, the length of the tap-root was 48 inches. Diameter of beet at crown $4\frac{1}{2}$ inches. The soil had dried out so much that only one or two small roots were found in the surface foot. The plant was obtaining most of its food and moisture in the second foot in depth where the most extensive root development was found. The third and fourth feet in depth had been hard and nearly dry all season. The tap-root found it very difficult to extend through a soil so hard and dry, and was forced to grow in quite a crooked course. This beet was of good shape but much smaller than beets on the more fertile and more easily penetrated soils. (Compare with Plates 14 and 15.) This plate furnishes a good illustration of the growth of sugar beets where the soil is too dry and hard and of low organic content.

Plate 13.—Beets on a clay loam of high fertility near Raymond, Alberta. Farmed by Mr. E. Gourlay.

The moisture content of the root zone of this field was very good until August 7. From August 7 to 21, and from September 1 to October 12, the field was too dry. The soil of this field is much the same as that of the Peterson

field of Plate 12. The Gourlay field, however, is much more fertile and for the most of the season contained more nearly the optimum amount of water than the Peterson field.

The following table gives a comparison of the two fields and shows the effect of fertility on root development:—

—	Length of tap-root		Diameter of beet at crown		Approximate square-feet of root surface shown on plate	
	Peterson	Gourlay	Peterson	Gourlay	Peterson	Gourlay
	inches	inches	inches	inches		
July 11	22	26	1¾	2	1·3	1·3
August 6	42	38	3½	4½	3·5	4·5
September 30	48	54	4½	7	4·5	12·0

From the above it is seen that on September 30, the beet on the fertile Gourlay field would weigh about four times as much as that from the Peterson field. The root system of the Gourlay beet on September 30, extended into and drew sustenance from a soil zone in cubic contents about four times that covered by the roots of the Peterson beet.

Plates 14 and 15.—Normal development on two soil types at Barnwell, Alta.

Plate 14 shows a normal development on a fertile, light, sandy-loam that had nearly an optimum moisture content in the root zone until the end of August, after which the field was too dry until the date of harvest. Plate 15 shows a normal development on a fertile clay-loam soil that had an optimum moisture content all season with the exception of a 10-day period in August when the first two feet in depth got too dry. This latter field was irrigated on August 18.

The following table gives a comparison of the two fields and shows the influence of soil texture on root development.

—	Length of tap-root		Diameter of beet at crown		Approximate area in square-feet of plane surface covered by roots on plates	
	Johnson	Valgardson	Johnson	Valgardson	Johnson	Valgardson
	inches	inches	inches	inches		
May 20	4	4	½	½	0·05	0·05
June 30	18	14	1	1¼	0·75	0·75
July 30	44	34	3½	3¾	5·0	4·50
September 30	54	50	5	5¾	16·0	9·00

This table shows that the beet on the clay-loam soil (Plate 15) was larger on September 30 than the beet on the sandy-loam soil (Plate 14), but that the roots of the latter drew supplies from a block of soil two or three times as large as the former.

The lighter soil was not so fertile as the heavy soil but offered less resistance to root penetration. Its lower fertility content and lighter texture encouraged greater root development.

Plate 16.—Abnormal Development of Beets on a wet clay soil, high in alkaline content.

Plate 16 shows the root development of sugar beets growing on a wet alkaline soil near Raymond, Alta. On July 10, these beets had a tap-root length of but 18 inches as compared with a length of 26 inches on the Gourlay field (Plate 13) some 2 miles distant, and of a similar heavy type of soil, but well drained and free from alkali. On August 2 to 6 the tap-root had attained

a length of 22 inches as compared with a length of 38 inches on the alkali-free Gourlay field. At this time the development shown is quite abnormal. The root development is nearly all in the surface foot where the alkali concentration is lower and where the soil contains more air. The roots have begun to thicken. On September 30, the tap-root is down 27 inches as compared with a length of 54 inches on the Gourlay field. The roots have become few in number and have thickened to diameters of $\frac{3}{4}$ inch to $1\frac{1}{4}$ inch at the base of the beet. The beet was malformed. A comparison with the above data of that obtained on this same field in 1927 shows a similar development for both seasons.

Depth of Root Penetration

Plate 17 shows the depth of tap-root penetration on six fields of beets as determined from excavations and measurements made during the 1928 season. Curve 1 shows the growth in depth of the tap-roots on the heavy alkaline clay soil at the sugar factory as shown on Plate 16. The development was nearly normal while the roots were in the surface foot, but slowed up quite noticeably as the roots penetrated the heavy wet subsoil. Curve 2 shows the development at Hillspring on a heavy wet clay soil, free, however, from alkali. Hillspring lies at a much higher elevation than Raymond and had a mean temperature during May some two degrees lower than that at Raymond. At the end of June the tap-root penetration was 9 inches, and 13 inches at the factory. The Hillspring beets got a later start but produced a more uniform growth during the season than did the factory beets. The root zones of both these fields are very much shallower than those of fields where the soil has less water and better aeration. The greatest length of tap-root at any time during the season after June 15, was found on the light fertile soil of the Johnson field at Barnwell. An average of curves 3, 4 and 5 will give the extent of the root zone on typical well drained clay soils during the 1928 season.

—	Depth of tap-root					Remarks
	May 31	June 30	July 31	Aug. 31	Sept. 30	
Average of 1 and 2....	4	11	20	27	30	Development retarded by lack of aeration.
Average of 3, 4, 5.....	$6\frac{1}{2}$	16	34	47	52	Normal for heavy soil.
No. 6................	$6\frac{1}{2}$	21	44	52	54	Normal for sandy soil.

Plate 18.—Annual variation in Root Development.

This graph shows the extent in depth of the root zone of two beet fields in 1927 and 1928. The Hillspring field is in a wet, heavy clay soil. The Welling field is in a well drained clay-loam soil. The depth of root penetration of the Hillspring field is limited by heavy wet subsoil. The depth of root penetration of the Welling field is about normal.

The 1928 season was more favourable as a whole than the 1927 season for root growth. Every month in 1928 except August was more favourable for root growth than the same months in 1927. The chart shows that on May 31, 1928, the Welling field had tap-roots $2\frac{1}{2}$ inches deeper than on the same date in 1927, due to the higher temperatures for the month this year. On June 30, the tap-roots of this field were 8 inches deeper and on July 31 they were 18 inches deeper than on the same date in 1927. Through June and July, 1928, the field had a better moisture supply than in 1927. August, 1928, was less favourable to the root-growth than August, 1927, on account of a lower temperature; the roots grew in length only 15 inches as compared with 19 inches in 1927. Septem-

ber, 1928, was more favourable than September, 1927, on account of drier, sunnier days. The 1928 beet on the Welling field had a diameter at crown about one-half inch greater than that of the 1927 beet.

Plate 19 shows the monthly increase in the crown diameter of beets on seven fields during 1928.

The Gourlay field was fertile, seeded early, thinned early, cultivated frequently, and got away to an early start. Its root development at all times during the season was ahead of the other fields upon which measurements were made.

The two Taber fields, Valgardson's and Johnson's, showed the next best growth. They were also fertile and well cared for.

The west Peterson field was drier throughout the season and not quite as fertile as the above described fields but produced a fair sized beet and had a root penetration nearly as deep up to the end of July. It was seeded about May 1. The east Peterson field had been heavily manured during the winter. Its surface soil got too dry in May and the seed did not germinate uniformly. It was irrigated on June 6. On July 1, the beets had a diameter of only one-eighth of an inch, while the beets of the west field had a diameter of nearly one inch. Growth on the east field was retarded nearly a month by dry surface soil in May.

Growth on the Merril and Reservoir fields was retarded mostly by a too wet subsoil. The Nelson field was too dry for germination and had to be reseeded June 3.

This graph shows the advantages of early seeding, fertile soil and proper moisture content.

PLATE 11

HILLSPRING

BEETS ON WET HEAVY CLAY SOIL AT ELEVATION 3800

THE SECOND AND THIRD FEET WERE MUCH TOO WET ALL SEASON FOR OPTIMUM GROWTH

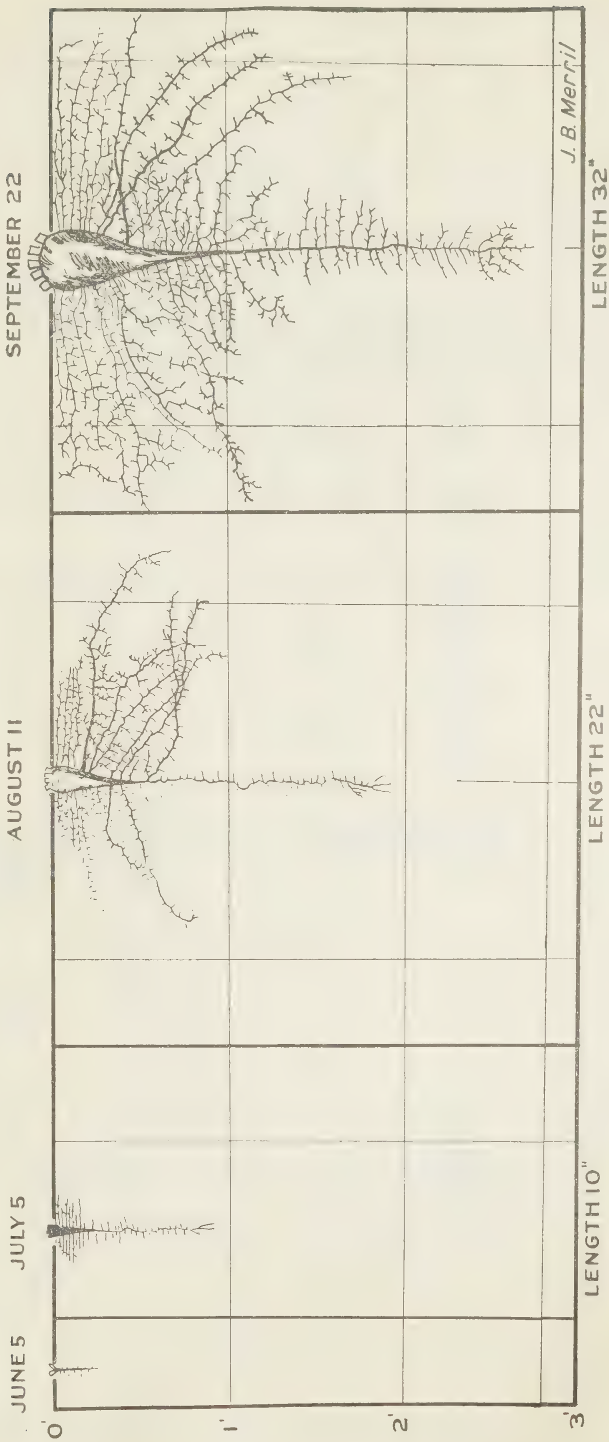


PLATE 12

WELLING

BEETS ON HEAVY CLAY LOAM SOIL, LOW FERTILITY. VERY DRY IN MAY AND AUGUST

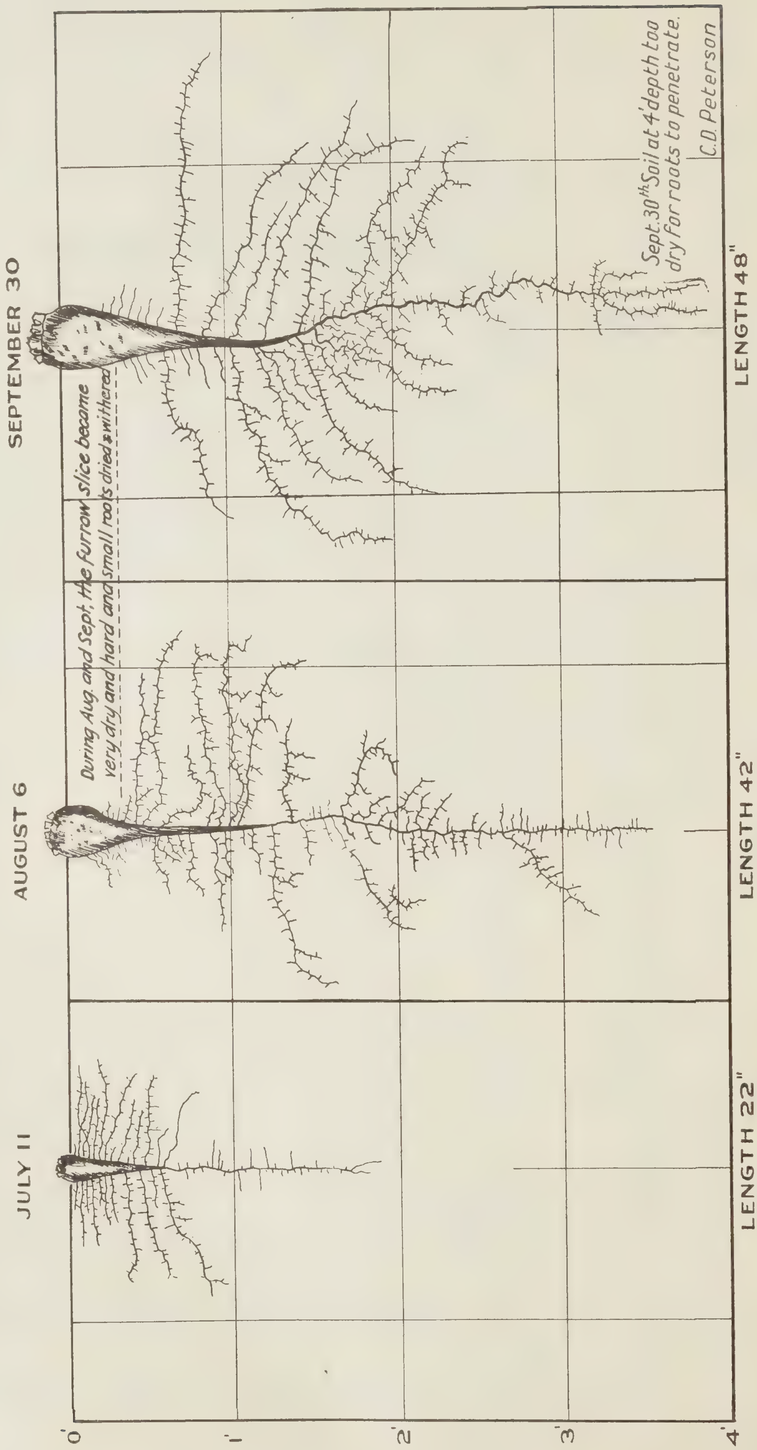


PLATE 13

RAYMOND

BEETS ON HEAVY CLAY LOAM SOIL, VERY FERTILE. NORMAL DEVELOPMENT

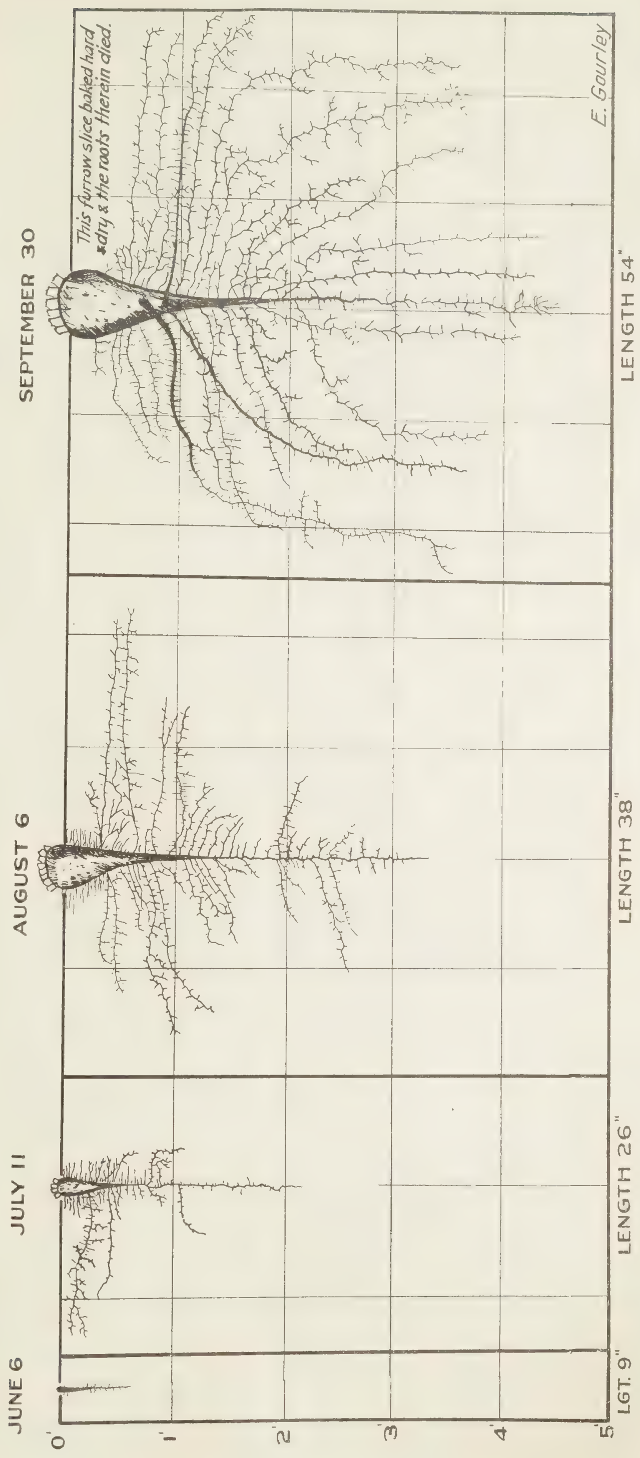


PLATE 14

BARNWELL

BEETS ON SANDY LOAM SOIL FOLLOWING SUMMER FALLOW. NORMAL DEVELOPMENT

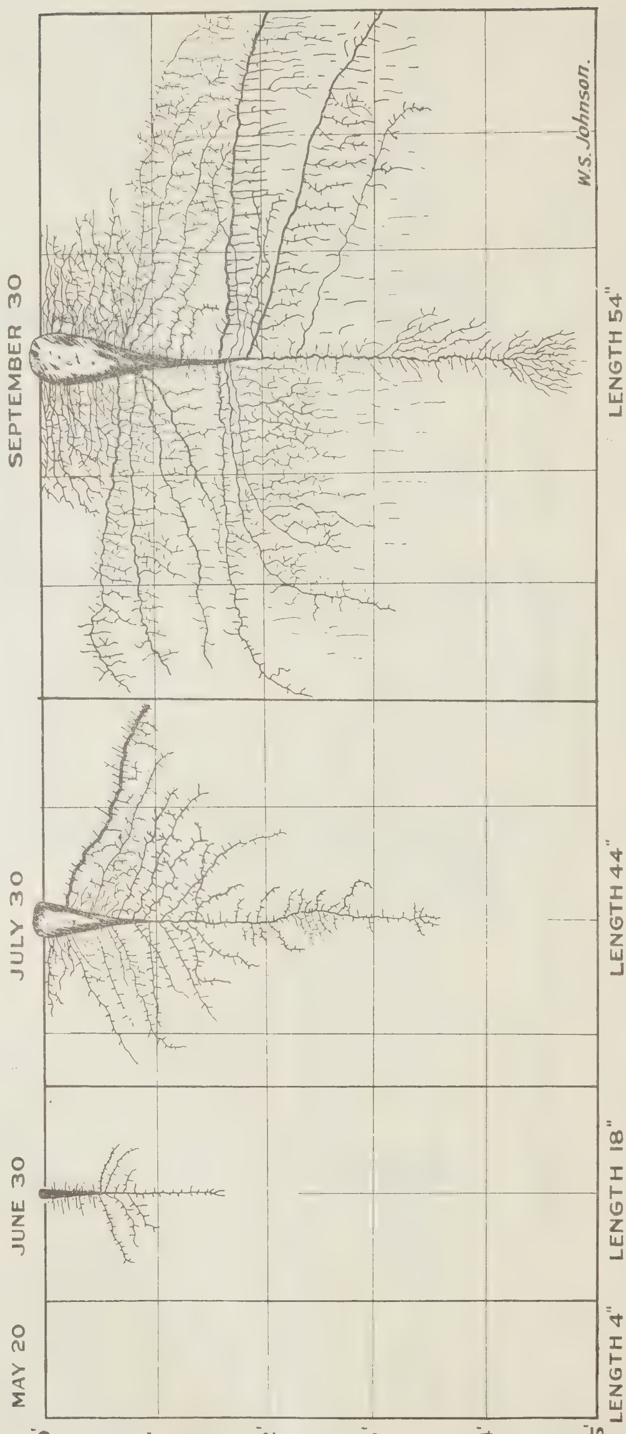


PLATE 15

BARNWELL

BEETS ON CLAY LOAM SOIL FOLLOWING SWEET CLOVER. NORMAL DEVELOPMENT

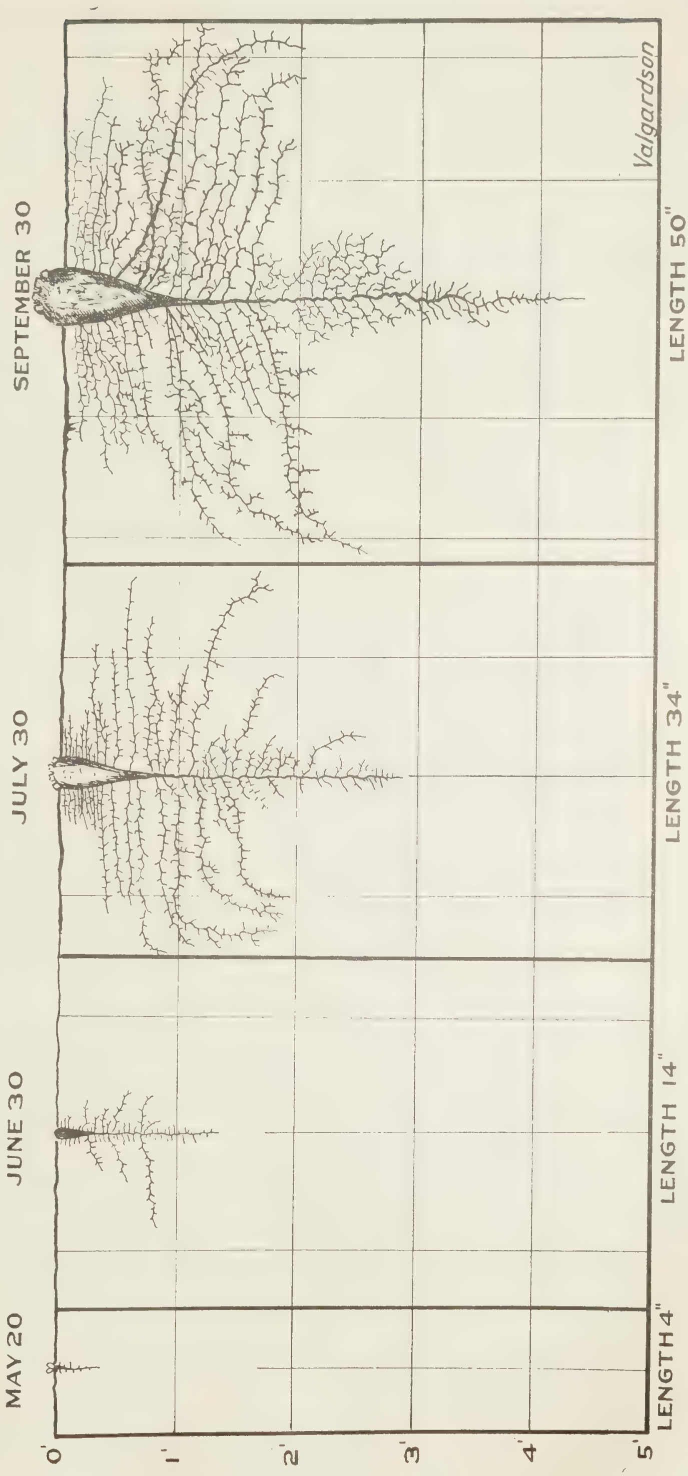


PLATE 16

RAYMOND

BEETS ON WET CLAY SOIL, HIGHLY ALKALINE, RAYMOND, ELEVATION 3100

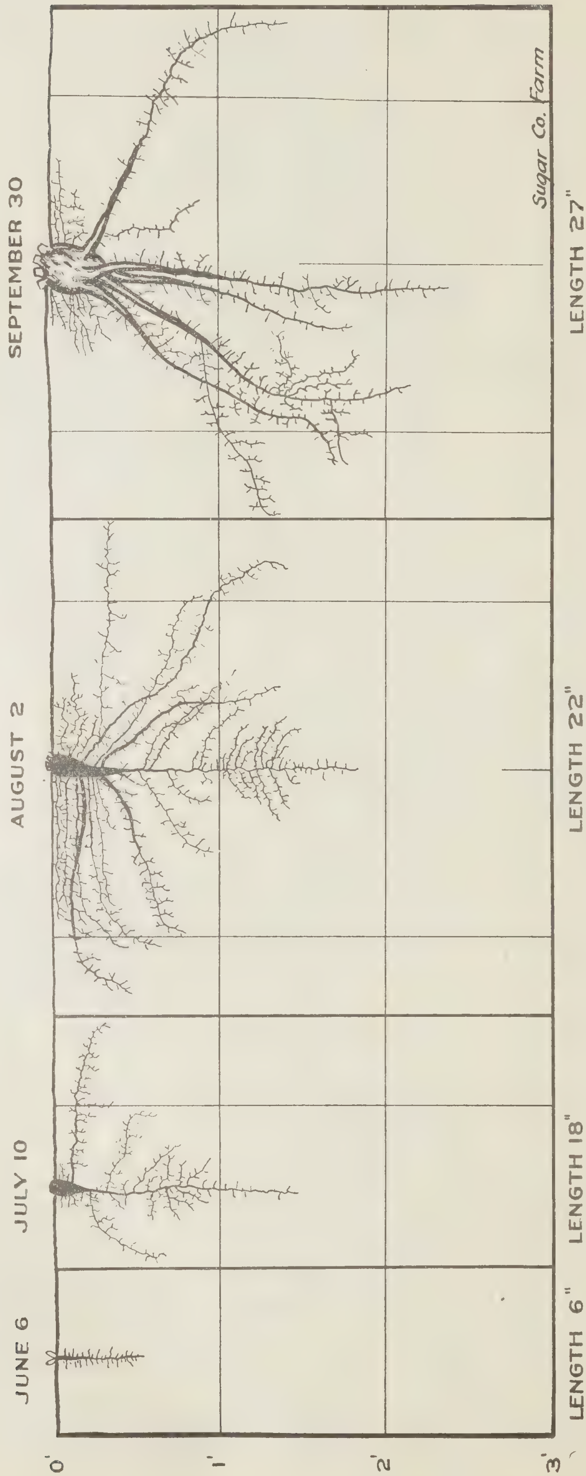


PLATE 17

EXTENSION IN DEPTH OF ROOT OCCUPIED ZONE 1928

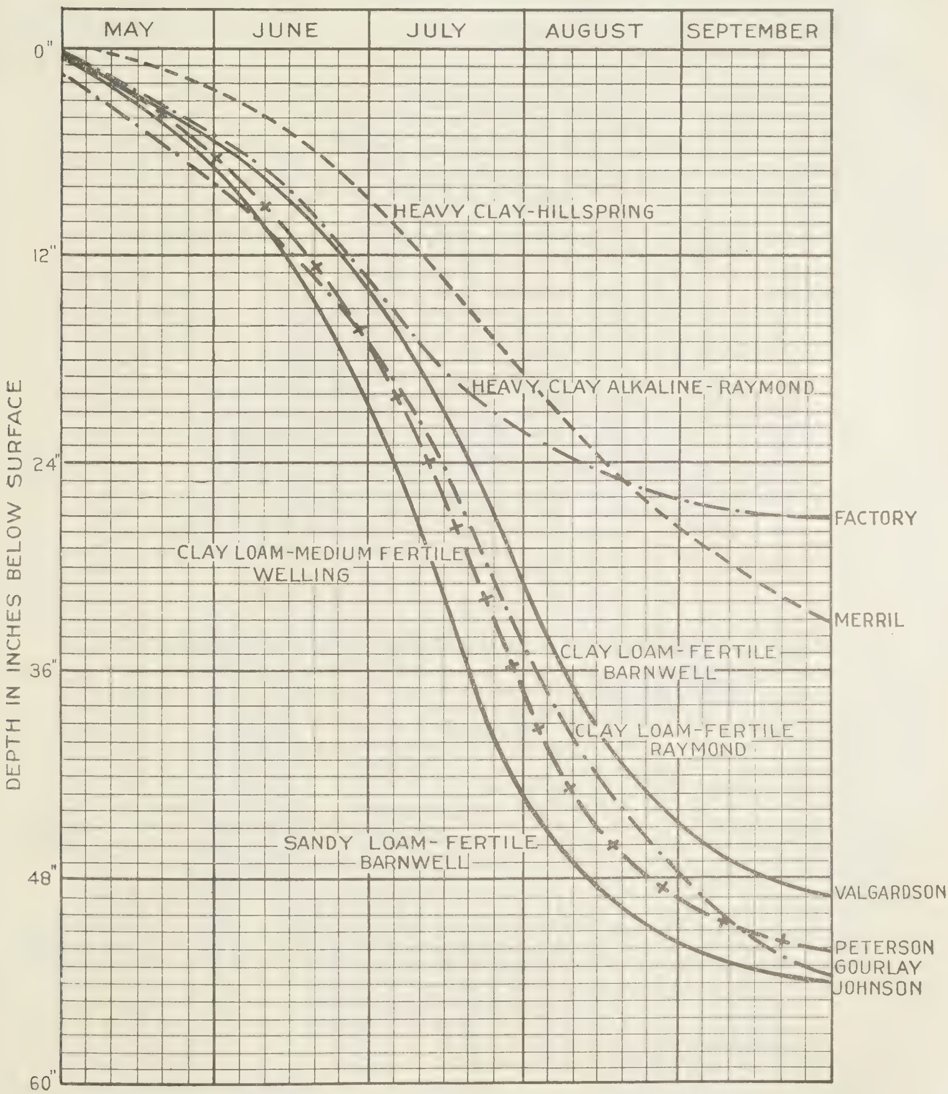
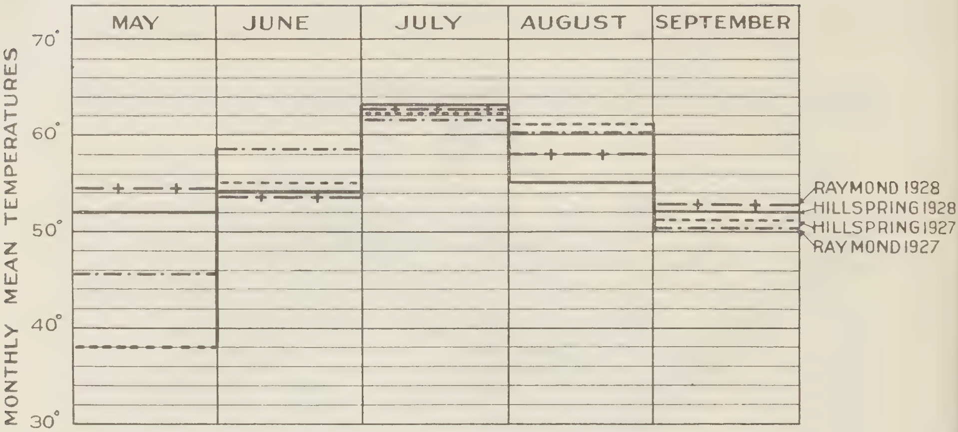


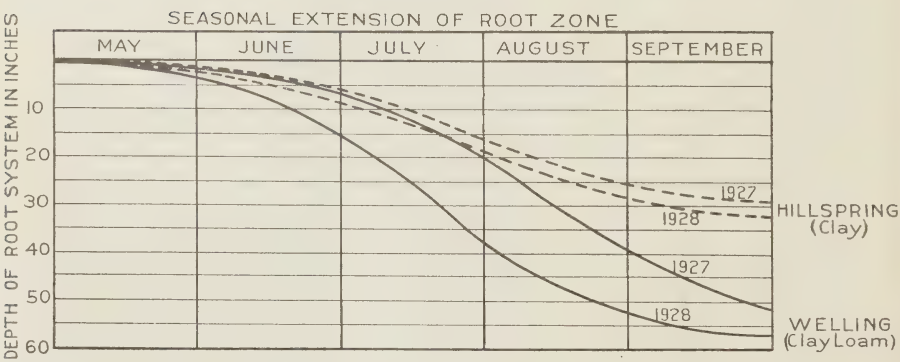
PLATE 18



MONTHLY PRECIPITATION IN INCHES

	MAY		JUNE		JULY		AUGUST		SEPTEMBER	
	1927	1928	1927	1928	1927	1928	1927	1928	1927	1928
RAYMOND	8·50	0·50	2·10	6·45	2·90	4·08	1·56	1·92	3·30	0·02
HILLSPRING	10·54	0·12	2·50	8·54	4·09	3·48	2·67	2·85	5·97	0·50

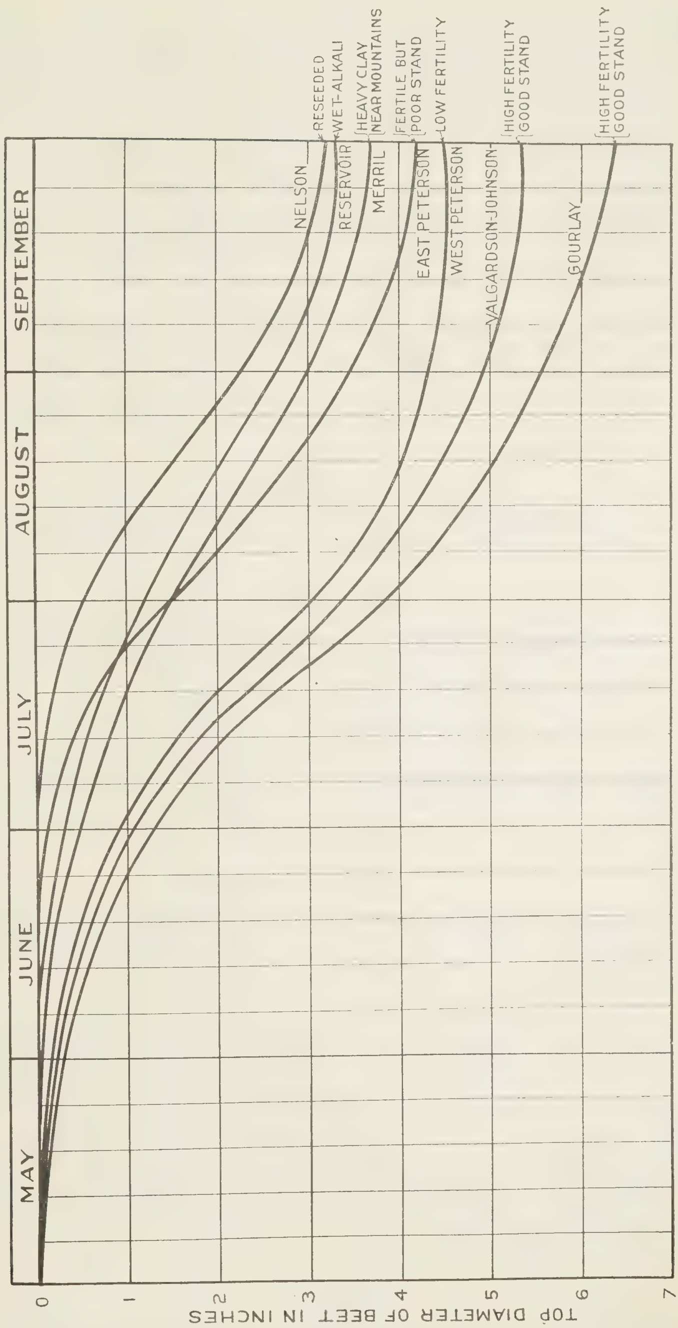
SEASONAL EXTENSION OF ROOT ZONE



MAY 1928 MORE FAVOURABLE FOR ROOT DEVELOPMENT THAN MAY 1927, DRYER & WARMER
JUNE 1928 " " " " " " JUNE 1927, BETTER MOISTURE SUPPLY
JULY 1928 " " " " " " JULY 1927, MORE RAIN
AUG. 1928 LESS " " " " " AUG. 1927, LOWER TEMPERATURE
SEPT. 1928 MORE " " " " " SEPT. 1927, HIGHER TEMPERATURE

PLATE 19

RATE OF GROWTH OF SUGAR BEETS 1928



FIELD OBSERVATIONS ON THE SEASONAL USE OF WATER BY SUGAR BEETS, 1928

This study was carried out along the same lines as that of 1927, but covered more territory. In 1928 observations were made on fourteen fields; three in the United district, seven in the Magrath-Sterling district, and four in the Barnwell-Taber district.

Plate 20 shows in acre-inches the total amount of water held in the soil to a depth of 4 feet for ten beet fields during the 1928 growing season.

The zone or range of optimum moisture content is shown shaded for each field. The irregular line shows the amount of available water contained in the field to a depth of 4 feet at any time during the season. Where this line lies above the shaded portion or zone of optimum moisture content the field is too wet, and where it lies below the shaded portion it is too dry for best growing conditions. A rise in the position of the line indicates an increase in the water-content of the field due to rainfall, irrigation, or seepage. A decline in the position of the line indicates the amount and rate of water used in growing the crop. This use, or loss, is due not only to that amount of water used by the plant as transpiration, but also to amounts lost from the soil as surface evaporation and deep percolation.

TABER DISTRICT

The seasonal moisture content of the two Johnson fields was favourable with the exception of one period during the first two weeks in June when the soil was too wet, and a second period during the month of September when the soil was too dry. The moisture content of the Valgardson field was within the optimum nearly all season. It would have been too dry after August 20 had it not received a 4-inch irrigation on that date. The moisture content of the Green field was below optimum—too dry—from May 1 until July 4. It was also too dry after September 3. The Johnson and Valgardson fields yielded between 12 and 14 tons per acre; the Green field about 7 tons per acre. The former fields were fertile and had sufficient moisture for germination and early growth; the latter field was too dry to germinate well in the spring and too dry for normal growth for more than half of the growing season.

RAYMOND DISTRICT

The seasonal moisture content of the Peterson field was normal until June 6. As the weather had been very dry during May it was considered advisable to irrigate on June 6, to provide for June requirements. Heavy rains commencing on this date and continuing through June and July made the field too wet until September 20. The yield was 7 tons per acre. The low yield was due to a poor stand caused by drying out of furrow slice in May and consequent poor germination of seed. The moisture content of the Gourlay field was optimum until June 10, too wet from June 10 to August 10, and very good from August 10 to the end of the season. Yield around 12 tons per acre. The moisture content of the A. Wild field was within the optimum range all season excepting from June 17 to July 13, when it was too wet, and from September 10 to 30, when it was too dry. Yield 9 tons per acre. This field is not as fertile as the Gourlay and Peterson fields.

UNITED DISTRICT

The moisture content of the Wood field was within the optimum range all season excepting from June 6 to July 4, when it was too wet. Yield 9 tons per acre. The Gibb field was too wet all season due to underground seepage water.

Plate 20

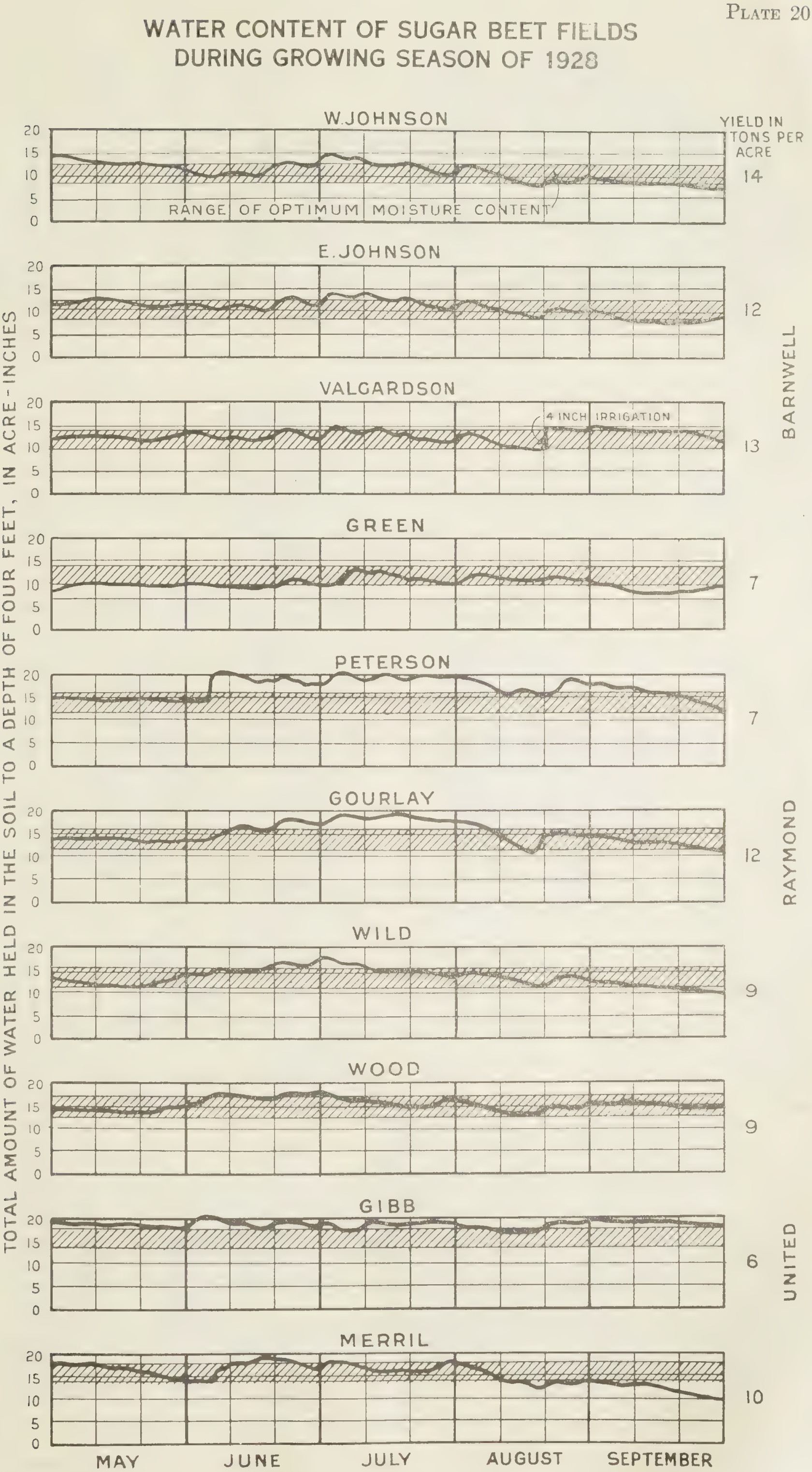
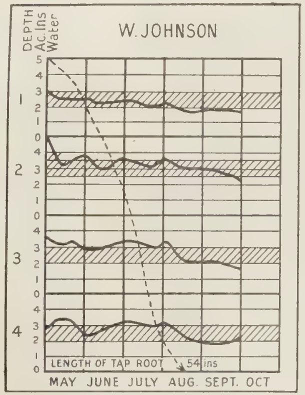
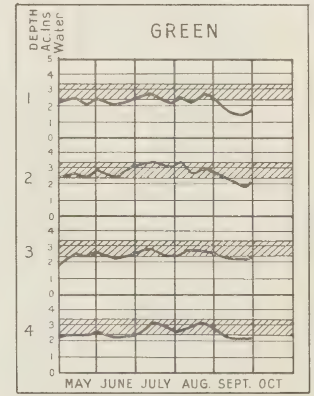

WATER CONTENT OF SUGAR BEET FIELDS
DURING GROWING SEASON OF 1928
W.JOHNSON
E.JOHNSON
VALGARDSON
GREEN
PETERSON
GOURLAY
WILD
WOOD
GIBB
MERRIL
YIELD IN TONS PER ACRE
14
12
13
7
7
12
9
9
6
10
RANGE OF OPTIMUM MOISTURE CONTENT
4 INCH IRRIGATION
BARNWELL
RAYMOND
UNITED
TOTAL AMOUNT OF WATER HELD IN THE SOIL TO A DEPTH OF FOUR FEET, IN ACRE-INCHES
0
5
10
15
20
MAY
JUNE
JULY
AUGUST
SEPTEMBER

PLATE 21

DEPARTMENT OF THE INTERIOR, CANADA
DOMINION WATER POWER AND RECLAMATION SERVICE

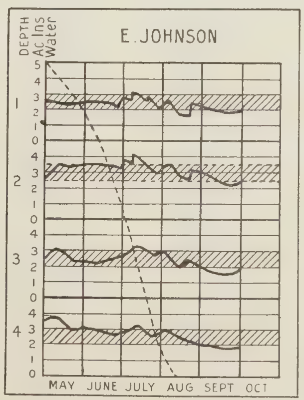
SEASONAL USE OF WATER BY SUGAR BEETS
1928
TABER DISTRICT

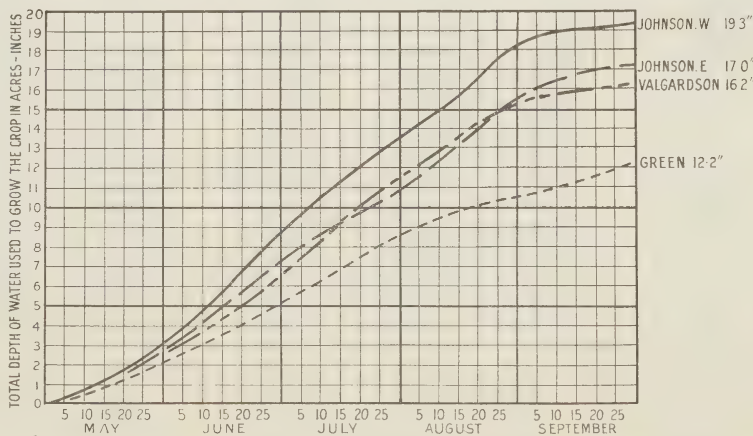




DEPTH OF WATER USED PER MONTH
IN ACRE INCHES

	MAY	JUNE	JULY	AUG	SEPT	TOTAL
JOHNSON.W	2·99	5 89	4 53	4·74	1·14	19 3″
JOHNSON.E	0·19	7·19	3·38	4·74	1·54	17 0″
VALGARDSON	0·00+·61	7·09	4 63	4 04	1 09	16 2″
GREEN	0·00+1·51	6 19	3·78	4·74	1 74	12 2″





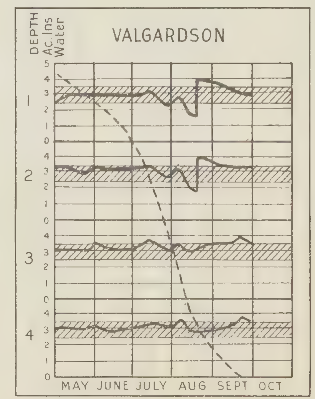
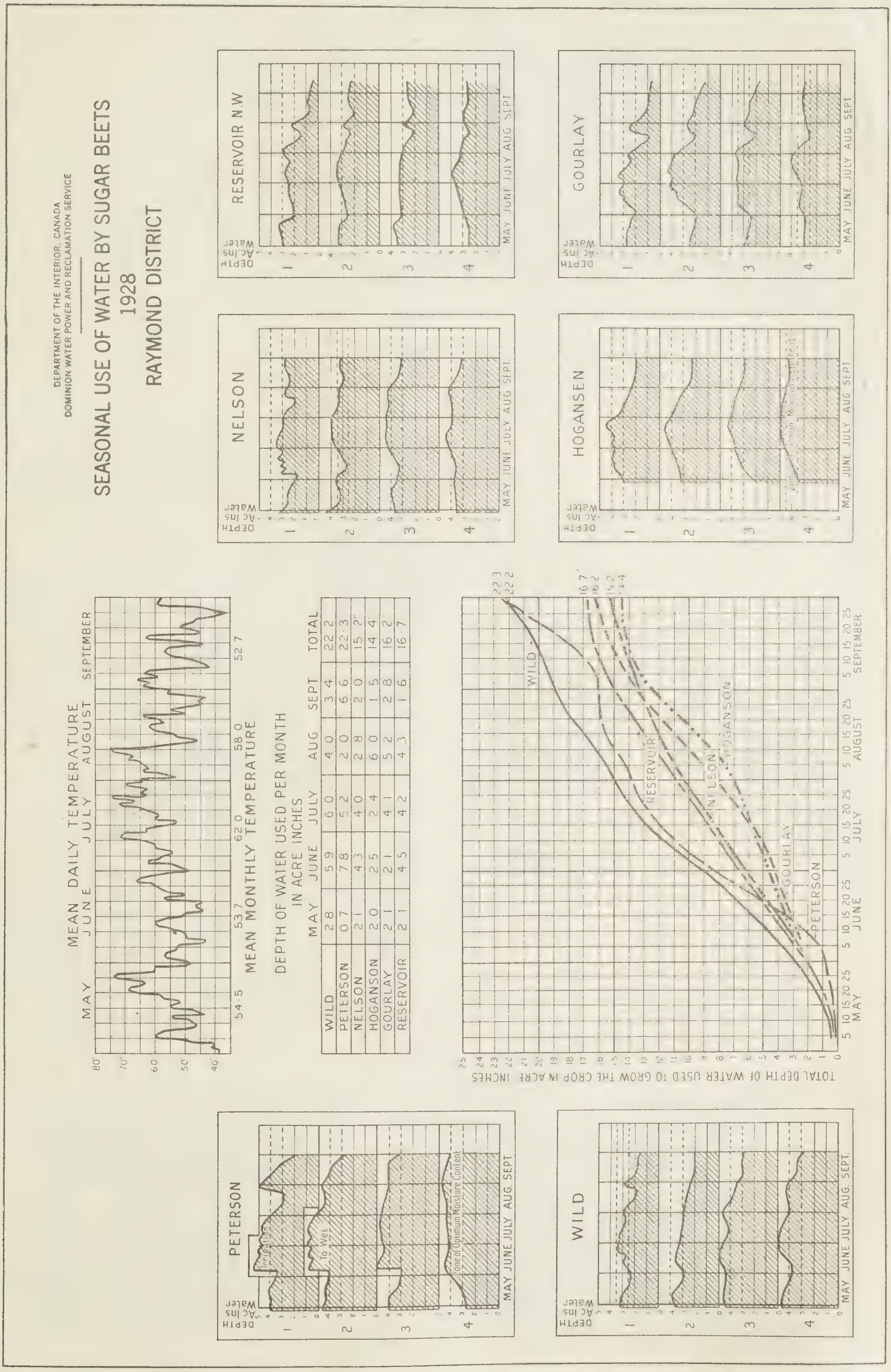


PLATE 22



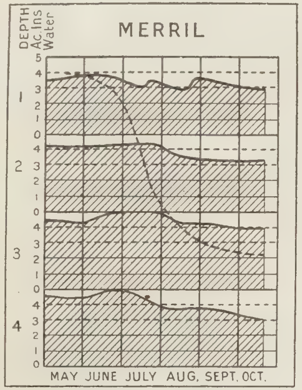
DEPTH OF WATER USED PER MONTH IN ACRE INCHES

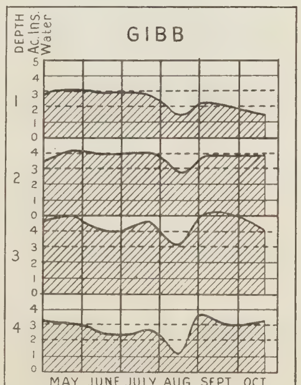
	MAY	JUNE	JULY	AUG	SEPT	TOTAL
WILD	2.8	5.9	6.0	4.0	3.4	22.2
PETERSON	0.7	7.8	5.2	2.0	6.6	22.3
NELSON	2.1	4.3	4.0	2.8	2.0	15.2
HOGANSON	2.0	2.5	2.4	6.0	1.5	14.4
GOURLAY	2.1	2.1	4.1	5.2	2.8	16.2
RESERVOIR	2.1	4.5	4.2	4.3	1.6	16.7

PLATE 23

DEPARTMENT OF THE INTERIOR, CANADA
DOMINION WATER POWER AND RECLAMATION SERVICE

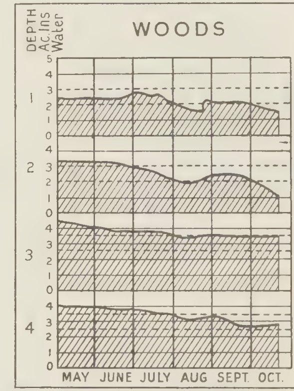
SEASONAL USE OF WATER BY SUGAR BEETS
1928
UNITED DISTRICT

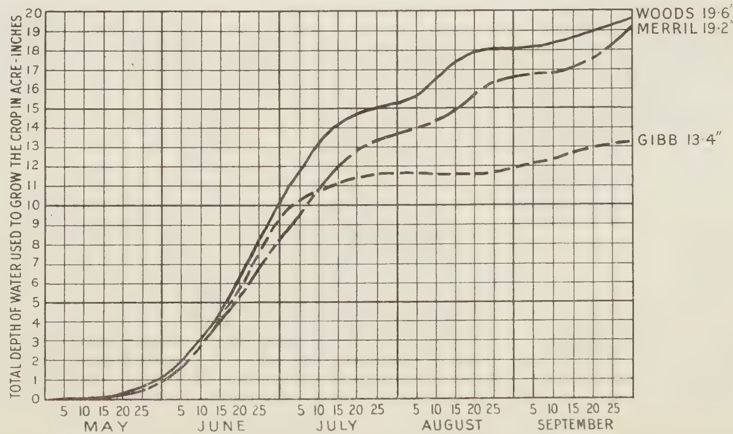




DEPTH OF WATER USED PER MONTH
IN ACRE INCHES

	MAY	JUNE	JULY	AUG	SEPT	TOTAL
WOODS	0·67	9·19	5 38	2·76	1·60	19·6"
MERRIL	0·02	7·89	5 53	3·10	2 65	19 2"
GIBB	0·00	9 71	1·83	0 60	1 25	13·4"





Yield 6 tons per acre. The moisture content of the Merril field was good up to June 13, too wet from that date until June 26, good from June 26 to August 10, and too dry from August 10 to September 30. Yield, 10 tons per acre.

The W. Johnson field should have had a 3-inch irrigation on August 15; the E. Johnson field a 2 or 3-inch irrigation on August 20; the Green field one 2-inch irrigation on May 1, and a second irrigation of 3 inches on September 1. The Wild field should have had a 4-inch irrigation August 1. The Merril field should have had a 4-inch irrigation on August 10.

Plate 21 shows (*a*) in centre of diagram the total depth of water used to grow the crop and the amount used during the different months or stages of growth for four fields in the Taber district; (*b*) in four small graphs the water content of each field for each foot in depth in relation to the optimum range; and, (*c*) by the dotted line in the small graphs, the rate and depth of tap-root penetration.

The west Johnson field used a total depth of 19·3 inches of water to grow the crop. The east Johnson field used 17·0 inches and the Valgardson field 16·2 inches. The Green field used only 12·2 inches; it was too dry most of the season, especially the first foot.

The first three fields show nearly normal use:—

—	May	June	July	Aug.	Sept.	Total	Approximate yield in tons per acre
West Johnson	3·0	5·9	4·6	4·7	1·1	19·3	14
East Johnson	0·2	7·2	3·4	4·7	1·5	17·0	12
Valgardson	0·0	6·5	4·6	4·0	1·1	16·2	13
Mean	1·1	6·5	4·2	4·5	1·2	17·5	13

Plate 22 shows the seasonal use on six fields in the Raymond district:—

—	May	June	July	Aug.	Sept.	Total	Approximate yield in tons per acre
A. Wild	2·8	5·9	6·0	4·0	3·4	22·1	9
C. D. Peterson	0·7	7·8	5·2	2·0	6·6	22·3	7
A. Nelson	2·1	4·3	4·0	2·8	2·0	15·2	6
N. Hogansen	2·0	2·5	2·4	6·0	1·5	14·4	6
E. Gourlay	2·1	2·1	4·1	5·1	2·8	16·2	12
Reservoir N.W	2·1	4·5	4·2	4·3	1·6	16·7	7
Mean	2·0	4·5	4·3	4·0	3·0	17·8	8

Plate 23 shows the seasonal use on three fields in the United district:—

—	May	June	July	Aug.	Sept.	Total	Approximate yield in tons per acre
Wood	0·6	9·2	5·4	2·8	1·6	19·6	9
Merril	0·0	7·9	5·5	3·1	2·7	19·2	6
Gibb	0·0	9·7	1·8	0·6	1·3	13·4	10
Mean	0·2	8·9	4·2	2·2	1·9	17·4	8
Mean of the three districts	1·1	6·6	4·2	3·6	2·0	17·5	10

The following table gives a comparison of the use in the Raymond district for two years, 1927 and 1928:—

—	May	June	July	Aug.	Sept.	Total	Average tons
Mean of 9 fields 1927.......	2·1	4·0	4·4	4·8	2·5	17·8	
Mean of 6 fields 1928.......	2·0	4·5	4·3	4·0	3·0	17·8	

Results of experiments on the duty of water for sugar beets conducted at Brooks in 1926 and 1927 showed that 18 inches of water produced from 91 to 97 per cent of the total possible yield. The figure obtained above as the average in the Raymond district for two years, 17·8 inches, is consistent with the findings at Brooks.

In general the low yields obtained in 1928 are due principally (1) to lack of proper stand caused by drouth in May, and crusting of surface after rains; (2) to late seeding and thinning; (3) to wet subsoil, and (4) to lack of soil fertility.

USE AND STORAGE OF WATER ON THE KOOLE DRY FARM NEAR MONARCH, ALBERTA

During 1927 and 1928, soil moisture tests were made on two "lands" of a farm cultivated by the "Strip" method, north of Monarch, Alberta, to determine the water-holding capacity of this type of soil, the amount of water that could be stored by correct summer-fallowing methods, and the amount of water used to grow a crop of dry-land wheat. The farm selected, belonging to Mr. H. Koole, was typical of the best dry farms in this district and has always been farmed in an efficient manner.

The following tables give the results of the 1927 and 1928 moisture determinations:—

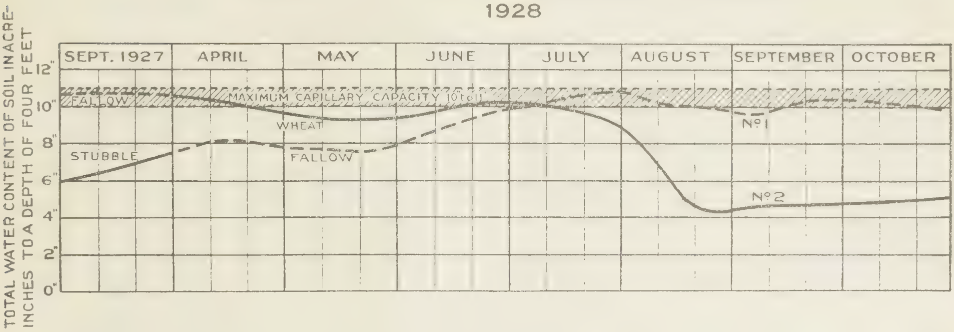
		1927		1928				
		Moisture Content in Acre-inches						
		May 20, 1927	Sept. 19, 1927	April 11, 1928	June 26, 1928	Aug. 1, 1928	Aug. 17, 1928	Oct. 22, 1928
Land No. 1..............	1	3·49	2·76	3·11	3·14	2·89	2·94	2·86
	2	3·88	1·45	2·63	2·90	3·02	2·70	2·75
	3	3·14	0·71	1·29	2·40	2·71	2·53	2·30
	4	2·61	0·87	1·09	1·37	2·32	1·89	2·18
Total...........	....	13·07	5·79	8·12	9·81	10·94	10·06	10·09
		Wheat		Summer-fallow				

		1927		1928				
		Moisture Content in Acre-inches						
		May 20, 1927	Sept. 19, 1927	April 11, 1928	June 26, 1928	Aug. 1, 1928	Aug. 17, 1928	Oct. 22, 1928
Land No. 2..............	1	3·00	3·22	2·73	3·13	2·27	1·47	2·42
	2	3·12	3·15	3·42	3·07	2·18	1·55	1·53
	3	2·86	2·24	2·70	2·39	2·20	1·01	0·53
	4	2·10	2·00	1·51	1·88	1·97	0·90	0·53
Total...........	....	11·08	10·61	10·36	10·47	8·62	4·93	5·01
		Fallow		Wheat				
Difference between the two fields.......................		1·99	4·82	2·24	0·66	2·32	5·13	5·08

These two "lands" are adjacent, each about one-half mile long and 320 feet wide. The sampling location on land No. 1 was 320 feet west of the sampling location on land No. 2. The soil of each is identical.

PLATE 24

SEASONAL MOISTURE CONTENT OF TWO STRIP-LANDS
ON
H. KOOLE DRY FARM NEAR MONARCH, ALBERTA.
1928



Maximum Capillary Capacity.—Soils differ in their power to retain water against gravity or the force that pulls the water toward the centre of the earth. This water-holding power varies with the texture of the soil from ½ acre-inch per foot in coarse sands to 4 or 5 inches per foot in clays. After the soil has reached its full capillary water-holding capacity, any additional amount of water received is lost from the root zone under consideration by percolation to deeper soil zones.

The fine silt loam soil at the Brooks Irrigation Experimental Station will hold around 4 inches of water per foot, or 16 inches in a 4-foot depth. Some of the heavy clay loam soils around Welling have a capacity of 20 inches in 4 feet. The sandy soil at the Strathmore Irrigation Experimental Station would hold only 6 inches in 4 feet.

Plate 24 shows that field No. 1 contained around 8 inches on June 1, and although it received 10·47 inches of water during June and July, only increased in water content 3·0 inches during that period. The maximum capillary capacity was reached around the first of July, after which this soil never contained more than 10·6 inches. The maximum capillary capacity for this soil to a depth of 4 feet is indicated at approximately 11·00 inches or 2·75 inches per foot in depth.

Gain or Loss During Winter.—Between September 19, 1927 and April 11, 1928, Field No. 1 gained 2·33 inches; field No. 2 lost 0·25 inch. The water content of field No. 1 on September 19, 1927, was 5·21 inches below maximum capacity, while that of field No. 2 was approximately at full capillary capacity. Field No. 1 gained its moisture before and after freeze-up.

Depth of Water Used to Grow the Crop—

	inches
Land No. 1, 1927—	
Spring moisture content	13·07
Rainfall received during 1927 season	11·64
	24·71
Fall moisture content	5·79
Water used to grow crop	18·92
Land No. 2, 1928—	
Spring moisture content	10·36
Rainfall received during 1928 season	13·05
	23·41
Fall moisture content	5·01
Water used to grow crop	18·40

The amount used to grow the crop was 18·92 inches in 1927 and 18·40 inches in 1928.

Depth of Water Stored by Summer-fallow—

(In root zone to a depth of four feet.)

Land No. 2, 1927—	inches
Spring moisture content	11·08
Rainfall received during 1927 season	11·64
	22·72
Fall moisture content	10·61
Lost from 4′ root zone by percolation and evaporation	12·11

This sample area contained 0·47 inch less water on September 19, 1927 than on May 20, 1927. On May 20, 1927 this field with a moisture content of 11·08 inches to a depth of 4 feet had reached its capillary water-holding capacity. Twelve inches of water received during the season from rains were lost by evaporation and percolation below the 4-foot depth.

Land No. 1, 1928—	inches
Spring moisture content	8·12
Rainfall during season	13·05
	21·17
Fall moisture content	10·09
Lost from 4′ root zone by percolation and evaporation	11·08

This field stored 1·97 inches of the season's rainfall. Field No. 1 contained in the spring of 1928, 2·96 inches less water than field No. 2 contained in the spring of 1927. It was not holding to capacity at the beginning of the season and had room to store some 2 inches of moisture from the 1928 rains. Field No. 2 was at, or slightly above, maximum capillary capacity at the beginning of the 1927 season and therefore could store no water from the 1927 rains. Non-available Water.

The soil moisture test made August 17, and October 22, 1928 showed the soil powdery and dry. It still contained to a depth of 4 feet, from 4 to 5 inches of water that was non-available to the plant roots.

This soil would hold to a depth of 4 feet at any one time not more than 6 or 7 inches of water available for plant use.

In the fall of 1927, the fallow contained 4·82 inches more water than the field cropped to wheat. In 1928 the fallow contained 5·08 inches more. In the spring the fallow contained in 1927, 1·99 inches more, and in 1928, 2·29 inches more than the stubble.

This soil is fine light sand and silt weighing only 70 pounds per cubic foot. Where this same type of soil is under irrigation it is possible to apply and retain in the 4 foot soil zone about 1½ acre-inches per foot in depth of soil or a 6-inch irrigation when the soil is very dry or near to the plant's wilting point.

The following table gives the depth of the soil zone occupied by beet-roots at different times in the growing season and the depth of irrigation water that the soils could retain in root zone if dry.

——	May 1	June 1	July 1	Aug. 1	Sept. 1	Oct. 1
Depth of root zone	0·3 Ft.	0·5 Ft.	1·5 Ft.	3·0 Ft.	4·0 Ft.	4·5 Ft.
Depth of irrigation	0·0 In.	0·75 In.	2·25 In.	4·5 In.	6·0 In.	

Up to July 1, never more than a 2-inch irrigation should be applied. From July 1, to October 1, the depth applied per irrigation will vary from 2 to 6 inches, depending on the depth of root zone and the amount of water contained in the soil before irrigating.

DRAINAGE SURVEYS AND INVESTIGATIONS

Drainage administration during the year 1928-29 has been confined again mainly to the development of small drainage schemes. The Department, however, has maintained supervision over the Low Water lake, Waterhen lake, McArthur Land Company and Western Manitoba Dairy Farms' schemes, and kept in contact with provincial drainage schemes in the provinces of Saskatchewan and Alberta.

Small Projects

In the provinces of Alberta and Saskatchewan there are a great many sloughs and small lakes which when properly drained make excellent hay lands and in some cases good agricultural lands. Provision is made under the Drainage Regulations for the reclamation of such lands upon application being made to the Department. All such applications are investigated by the Department and, when schemes are determined to be feasible and economical, surveys are made from which plans are prepared and the applicants are allowed to acquire the reclaimed lands either by purchase or supplementary patent, depending upon the nature of the ownership of the balance of the quarter sections affected.

During 1928-29 the weather has been exceptionally favourable for construction work and much progress has been made in work in connection with drainage schemes in the Edmonton district. Drainage projects in this district, with a small number of exceptions, have attained a fair amount of success but few have yet reached full efficiency. This is due largely to lack of capital on the part of the applicants to carry the construction of the necessary works to completion and to a desire to utilize partially reclaimed land. Among other schemes in the Edmonton district special efforts were directed to advance the Low Water Lake project to a revenue producing stage and surveys were made under the direction of the Department engineers to determine the most feasible means of bringing about the desired result and to lay out work for construction during the coming year.

One hundred and eleven small schemes were inspected, twenty-four applications dealt with, seven schemes authorized, six sales of Dominion land made and fifty-six applications cancelled.

Provincial Drainage Districts

A number of drainage schemes in the provinces of Alberta and Saskatchewan were authorized by this Department. Districts have since been organized and works constructed under provincial drainage laws.

Saskatchewan Provincial Districts.—During the year 1928-29 considerable progress was made in the development of drainage projects in the province of Saskatchewan. Work was completed in Drainage District No. 28, known as the Grand Coulee Drainage District. Construction in connection with the enlargement and extension of Ditch No. 2 in Drainage District No. 13 in the vicinity of Lewvan was also completed.

A number of drainage projects were under consideration, including a large project covering flooded lands in the vicinity of Kronau on Wascana creek, but no definite decision has as yet been reached.

A further sale of Crown lands in the Moose Range Drainage District was held in October when thirty quarter sections were sold. It is believed that the proceeds from the sale of lands in the two Moose Range districts will finance the entire cost of construction.

Alberta Provincial District.—During the past year application for the formation of a drainage district from the residents of the lands surrounding Big lake near St. Albert was received. A vote was taken on the formation and the district was formed under the name of "Big Lake Drainage District" and a board of trustees was elected. No further action has as yet developed.

The five provincial districts now in operation are the Holden, Daysland, Viking, Hay Lake and Dickson. Quite extensive repairs to laterals were made in the Holden district during the year and detailed surveys of the main ditches were made and repair work on these ditches planned for the coming season. Repair work was also carried out in the Viking district. All the districts operated successfully during the year and are in good financial condition.

Waterhen Lake Drainage Project

Weather conditions during the spring of 1928 were especially favourable for seeding operations on the Waterhen Lake project and these were completed in ample time. Prospects were good for a fair yield but unfortunately the crop of barley was below average owing to unfavourable weather conditions in the early fall.

The hay yield as usual was good this season, some 300 tons of natural hay having been cut from 200 acres. It would appear that the reclaimed land is well suited for the growth of fodder crops. Timothy, bromus, sweet clover, etc., can be successfully grown.

Up to the present the lack of a supply of water for winter has prevented the lessees from running stock on the place. A spring has, however, been discovered a short distance from the farm buildings which may solve the problem.

Observations were continued this season to determine the depth of the water-table. These showed the level to be considerably lower than that observed at the same time last year. This difference was contributed to in part by the dryness of the season and the presence of newly constructed surface ditches but there also appears to be no doubt that the lake bottom is gradually drying out.

During the season a great deal of work has been done in cleaning out old surface ditches and excavating new ones. As a result some 16 miles of surface ditches were put in efficient operation during the summer with favourable results.

Low Water Lake Project

In connection with this scheme of 7,840 acres situated in townships 50 and 51, ranges 4 and 5, west of the fifth meridian, further surveys were made for the purpose of locating "catch-water" ditches around the northern part of the lake. Arrangements are now being made by the Northern Alberta Drainage Company to carry out this work, involving approximately 40,000 cubic yards of excavation, this season.

East and West Prairie Rivers Project

An investigation was carried out by the Department to determine the feasibility and cost of reclaiming some 40,000 acres of land that is flooded, annually, by the East and West Prairie and Heart rivers in townships 74, 75 and 76, ranges 15, 16, 17 and 18, west of the fifth meridian. It was reported that the reclamation could be achieved at a cost of $250,000 by diverting the flood flows of the West Prairie and Heart rivers to the Smoky river in the adjoining drainage basin to the west.

Seine River Scheme

The Department carried out an investigation to ascertain what remedial works would be required and their cost to reclaim some 45,000 acres of land,

situated in the Seine River valley, Manitoba. This land is low lying and subject to annual overflow from the river. The cost of the necessary cut-off canals, diversion channels and drainage ditches was estimated as $268,000.

Icelandic River Scheme

Investigations were carried out to determine the feasibility and cost of reclaiming a considerable area of land adjoining the Icelandic river in townships 22 and 23, ranges 1, 2 and 3, east of the principal meridian, which is periodically flooded by the overflow of this river. The suggested remedy involves the construction of an auxiliary drainage canal for a length of 16 miles to intercept about 25 per cent of the run-off tributary to the river and to conduct it to an adequate outlet other than the existing river channel. The cost was estimated as $110,000.

Manitoba Dairy Farms Limited, Western Project

During the year an inspection was made of the ditches in townships 4 and 5, range 9, east of the principal meridian, constructed by the Manitoba Dairy Farms Limited in the fall of 1927. These ditches were found to be functioning quite satisfactorily and considerable evidence was observed of their beneficial effect in reclaiming the adjoining land. This inspection was made jointly by engineers of the department and of the provincial Government.

Manitoba Dairy Farms Limited, Eastern Project

An investigation was carried out by engineers of the Department to ascertain the feasibility, desirability, and cost of the proposed eastern project of the Manitoba Dairy Farms Limited in townships 1 to 11, ranges 9 to 17, east of the principal meridian. This drainage application is now receiving the attention of the Department.

Kootenay Flats Project

This department, at the instance of the Department of Indian Affairs, carried out a full field investigation of the proposed scheme of the Creston Reclamation Company in Kootenay Flats, British Columbia. The scheme includes 8,600 acres of which about 2,000 acres are Indian lands.

FUR FARMING

The northward spread of agricultural settlement has encroached on the wild areas formerly devoted to trapping and the ever growing market for furs, together with the decreasing area available to the fur bearers, has led to the establishment of farms where these animals are reared in captivity. Although originally confined almost exclusively to foxes, the industry is now interested to a large extent in the rearing of muskrats. This fur is in great demand and while the price per skin is comparatively low—$2.50 to $2.75 last season—it stood third in value in the list of furs exported last year, being exceeded only by fox and beaver in the order named.

To foster this industry the federal Government recently reached an agreement with the provinces of Alberta and Saskatchewan whereby vacant and available Dominion lands containing suitable water or marshy areas are leased to the provinces free of charge. The provinces, in turn, sub-lease these areas to individuals who wish to engage in fur-farming which is carried on under provincial regulations. The interest taken in this industry is shown by the fact that during the past fiscal year 603 applications were received and 226 such leases were issued by the Department of which 7 were cancelled, not being required by the province. The total area covered by these leases, excluding those cancelled is 149,063·2 acres. The total area covered by leases issued to date to the provinces of Alberta and Saskatchewan is 161,701·1 acres, of which 6 leases covering 1,835·8 acres have been issued to the last named province.

CLASSIFIED LIST OF PUBLICATIONS

WATER-POWER

The reports pertaining to Water-power, published by the Dominion Water Power and Reclamation Service, with the exception of the Annual Reports, have been called Water Resources Papers, and have been numbered 1, 2, etc.

Annual Reports previous to 1913 are included with the Annual Report of the Department of the Interior, and can be secured from the secretary of the department.

Annual Reports for the fiscal years ended March 31, from 1913, to 1929, are available for distribution. That for 1924 is the first report combining the activities of the Water Power and Reclamation divisions of the Service.

REPORTS OF SPECIAL OR GENERAL INTEREST

Water Resources Paper No. 2.—Report on Bow River Power and Storage Investigations, Bow river west of Calgary, by M. C. Hendry, chief engineer in charge of surveys. This is a complete study of the Bow river west of Calgary. It deals with meteorological conditions and their effect on run off and ice formation. Existing and possible power and storage developments, together with maps and plans are appended complete. Published 1914. Out of print.

Water Resources Paper No. 3.—Report on Power and Storage Investigations. Winnipeg River, by J. T. Johnston, chief hydraulic engineer Dominion Water Power Branch. A complete study based on field surveys and office computations of the Winnipeg River basin; deals fully with history, international considerations, topography, climate, storage possibilities; describes existing and gives preliminary designs and estimates for possible power developments; discusses other sources of power and the power market. Maps, plans and all relevant data are appended. Published 1915. Out of print.

Water Resources Paper No. 5.—Preliminary Report on the Pasquia Reclamation Project, by T. H. Dunn, chief engineer in charge of Reclamation Survey. This is a progress report of investigations carried out to determine the possibility of lowering the level of Cedar lake and its effect in a general scheme for declaiming the low-lying lands contiguous to the Saskatchewan river in the Pasquia region. Published 1914. Out of print.

Water Resources Paper No. 6.—Report on cost of various sources of power for pumping in connection with the South Saskatchewan Water Supply Diversion Project, by H. E. M. Kensit. It deals with the problem of power for pumping water from the South Saskatchewan river for the supply of cities and towns in the central portion of south Saskatchewan. Published 1914. Out of print.

Water Resources Paper No. 7.—Report on the Manitoba Water-powers, by D. L. McLean, S. S. Scovil and J. T. Johnston, compiled for the Manitoba Public Utilities Commission. A general survey of the water-power situation in Manitoba, with all available general information and hydrometric data published to date in condensed form concerning rivers in Manitoba. Published 1914. Replaced by No. 56.

Water Resources Paper No. 10.—General Guide for Compilation of Water-power Reports of the Dominion Water Power Branch, prepared for the guidance of field engineers of the Dominion Water Power Branch, by J. T. Johnston, chief hydraulic engineer. Published 1915. Limited edition.

Water Resources Paper No. 11.—Second Report on the Pasquia Reclamation Project by T. H. Dunn, chief engineer in charge of Reclamation Survey. This is a continuation Report based on further investigations as outlined under Water Resources Paper No. 5. Published 1915. Out of print.

Water Resources Paper No. 12.—Report on Small Water-powers in Western Canada, and discussion on sources of power for the Farm, by A. M. Beale. Part I is a brief description of certain small western water-power developments. Part II gives an analysis of requirements and cost data for the farm power supply. Published 1915. Out of print.

Water Resources Paper No. 13.—Report on the Coquitlam-Buntzen Hydro-Electric Development. A complete description of the project and of the details of construction, with plans, diagrams and illustrations, by G. R. G. Conway, chief engineer of the British Columbia Electric Railway Company, Limited. Published 1915.

Water Resources Paper No. 16.—Water powers of Canada. A series of five pamphlets in one volume covering the water-power situation in Canada, prepared for distribution at the Panama Pacific Exposition, San Francisco, 1915, by G. R. G. Conway, consulting engineer, Toronto; Percival H. Mitchell, consulting engineer, Toronto; H. G. Acres, hydraulic engineer, Hydro-Electric Power Commission, Ontario; F. T. Kaelin, assistant chief engineer, Shawinigan Water and Power Co., Montreal; K. H. Smith, engineer, Nova Scotia Water Power Commission, Halifax, N.S. Published 1916. Out of print.

Water Resources Paper No. 17.—Canadian Hydraulic Power Development and Electric Power in Canadian industry, by Charles H. Mitchell, consulting engineer to Dominion Water Power Branch. Part I deals with progress of utilization, features in design, construction and operation specially applicable to Canada. Description of certain typical Canadian water-power developments. Part II analyses the uses, growth and future of electrical power in Canadian industry. Published 1916. Out of print.

Water Resources Paper No. 20.—Report on the Interest Dependent on Winnipeg River Power, with Special Reference to the Capital Invested and the Labour Employed, by H. E. M. Kensit. A detailed study of the industrial growth and future power requirements of the district tributary to the Winnipeg River power sites. Published 1917. Out of print.

Water Resources Paper No. 27.—Directory of Central Electric Stations in Canada to January 1, 1919, compiled by J. T. Johnston, assistant director, Dominion Water Power Branch. Comprises an analysis of the central electric census statistics and a directory of the stations. Published 1919. Out of print. Replaced by No. 55.

Water Resources Paper No. 32.—Water Resources Index Inventory, by J. T. Johnston. Description of the Index Inventory System for recording and collating the water resources data of the Dominion. Published 1922. Out of print.

Water Resources Paper No. 33.—Directory of Central Electric Stations in Canada, to November 1, 1922. Comprises an analysis of the central electric station statistics and directory of the stations. Out of print. Replaced by No. 55.

Water Resources Paper No. 55.—Directory and analysis of Central Electric Stations in Canada, to May 1, 1928. Price, 50 cents.

Water Resources Paper No. 56.—Water Powers of Manitoba. Administration, developed power and available undeveloped power, by C. H. Attwood, district chief engineer. Published 1926.

Water Resources Paper No. 60.—Water Powers of Canada. A general review of the water-power resources of Canada as to investigation, administration, developed power, use of power in industry and available undeveloped power, by J. T. Johnston, Director of Water Power and Reclamation. Published 1927.

SURFACE WATER SUPPLY REPORTS

ATLANTIC DRAINAGE SOUTH OF ST. LAWRENCE RIVER, INCLUDING NOVA SCOTIA, NEW BRUNSWICK, PRINCE EDWARD ISLAND, AND SOUTHEASTERN QUEBEC

Water Resources Papers Nos. 29, 37, 45, 52 and 63.—Surface water supply of Canada. Reports on hydrometric surveys covering the Atlantic drainage south of the St. Lawrence river, including Nova Scotia, New Brunswick, and Prince Edward Island and south-eastern Quebec, for the climatic years ending September 30, 1919 to 1928, by K. H. Smith and K. G. Chisholm, district chief engineers.

ST. LAWRENCE AND SOUTHERN HUDSON BAY DRAINAGE IN QUEBEC

Water Resources Papers Nos. 41, 48 and 58.—Surface water supply of Canada. Reports on hydrometric surveys covering the St. Lawrence and southern Hudson Bay drainage in Quebec for the climatic years ending September 30, 1923 to 1927, by Leo G. Denis, district chief engineer.

ST. LAWRENCE AND SOUTHERN HUDSON BAY DRAINAGE IN ONTARIO

Water Resources Papers Nos. 28, 34, 38, 42, 49 and 58.—Surface water supply of Canada. Reports on hydrometric surveys covering the St. Lawrence and southern Hudson Bay drainage in Ontario for the climatic years ending September 30, 1920 to 1927, by S. S. Scovil and N. Marr, district chief engineers.

ARCTIC AND WESTERN HUDSON BAY DRAINAGE (AND MISSISSIPPI DRAINAGE IN CANADA) IN ALBERTA, SASKATCHEWAN, MANITOBA, EXTREME WESTERN ONTARIO, AND NORTHWEST TERRITORIES

Water Resources Paper Nos. 4, 19, 22, 24 and 26.—Surface water supply of Canada. Reports on hydrometric surveys in Manitoba, from January 1, 1912, to September 30, 1919, by M. C. Hendry and C. H. Attwood, chief engineers. No 4 contains a gazetteer of lakes and streams in Manitoba.

Water Supply Bulletins Nos. 1 to 11.—Surface water supply of Canada. Reports on hydrometric surveys in Alberta and Saskatchewan from 1908 to September 30, 1919, by P. M. Sauder and A. L. Ford, chief hydrometric engineers, Reclamation Service. Out of print.

Water Resources Papers Nos. 31, 36, 40, 44, 46, 50, 54, 57 and 62.—Surface water supply of Canada. Reports on hydrometric surveys covering the Arctic and western Hudson Bay drainage (and Mississippi drainage in Canada) in Alberta, Saskatchewan, Manitoba, extreme western Ontario and Northwest Territories, for the climatic years ending September 30, 1920 to 1928, by C. H. Attwood and A. L. Ford, district chief engineers. Previous to 1919-1920 the surveys in Alberta and Saskatchewan were carried on and the results published by the Reclamation Service, Department of the Interior.

PACIFIC DRAINAGE IN BRITISH COLUMBIA AND THE YUKON TERRITORY

Water Resources Papers Nos. 1, 8, 14, 18, 21, 23, 25, 30, 35, 39, 43, 47, 51, 53, 59, 61 and 65.—Surface water supply of Canada. Reports on hydrometric surveys covering the Pacific drainage in British Columbia and the Yukon Territory from May, 1911, to September 30, 1928. No. 1 is by P. A. Carson, chief engineer, the others by R. G Swan and C. E. Webb, district chief engineers. No. 1 contains an outline of the history of the Railway Belt with special reference to its administrative, legal and physical problems in regard to water, and a gazetteer of the lakes and streams in British Columbia.

MAP

Water-powers of the Dominion of Canada prepared in connection with the second World Power Conference, Berlin, Germany, 1930.

RECLAMATION

Drainage Regulations.

Irrigation Regulations.

Annual Irrigation Reports.—1894-1911. (Out of print.)

Annual Irrigation Reports.—1912 to 1915. (Out of print.)

Irrigation Surveys and Inspections Reports.—Fiscal years 1915 to 1918-19. (Out of print.)

Annual Report of the Reclamation Service.—1919-20 to 1922-23.

Annual Report of the Dominion Water Power and Reclamation Service.—1923-24, to 1928-29.

Annual Stream Measurements Reports of Alberta and Saskatchewan.—Water Supply Bulletins Nos. 1-11, 1909-1919. (Out of print.) (Continued in Water Resources Papers Nos. 31, 36, 40, etc.)

Western Canada Irrigation Association Reports.—(1st to 11th Convention, 1907-1917). (Out of print.)

International Irrigation Congress Report (1914).

Bulletin No. 1.—Irrigation in Alberta and Saskatchewan. (Consisting of a Synopsis of the Irrigation Act and its Administration.)

Bulletin No. 2.—Alfalfa Culture. (Out of print.)

Bulletin No. 3.—Climatic and Soil Conditions, C.P.R. Irrigation Block.

Bulletin No. 4.—Duty of Water Experiments and Farm Demonstration Work. (Out of print.)

Bulletin No. 5.—Farm Water Supply.

Bulletin No. 6.—Irrigation Practice and Water Requirements for Crops in Alberta. (Out of print.) See Bulletin No. 7.

Bulletin No. 7.—Irrigation Practice and Water Requirements for Crops in Alberta (Revised edition of Bulletin No. 6.)

Pamphlets:

- Address by Mr. S. G. Porter—"Practical Operation of Irrigation Works."—Extract from W.C.I.A. Report, 1914. ....
- Address by Dr. Rutherford—"Inter-dependence of Farm and City."—Extract from W.C.I.A. Report, 1914.
- Address by Mr. Don. H. Bark.—"The Actual Problem that Confronts the Irrigator."—Extract from W.C.I.A. Report, 1914.
- Address by Mr. Don. H. Bark—"Practical Irrigation Hints for Alberta."—Extract from W.C.I.A. Report, 1915.
- Address by Mr. Don. H. Bark—"Alfalfa Growing."—Extract from W.C.I.A. Report, 1915.
- "Practical Information for Beginners in Irrigation" (by W. H. Snelson, A.M.E.I.C.).

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Water Resources Papers, and Irrigation and Drainage Reports, as listed at the end of this report are issued gratis, with the exception of Water Resources Paper No. 55, for which a charge of 50 cents is made. These can be had on application to the Director of Dominion Water Power and Reclamation Service, Department of the Interior, Ottawa.